REAUTHORIZATION OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION ACT OF 1977

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE

OF THE

COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

AND THE

SUBCOMMITTEE ON
SCIENCE, RESEARCH AND TECHNOLOGY

OF THE

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SCIENCE AND TECHNOLOGY
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ON

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*On assignment to Budget Committee for 97th Congress.

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REAUTHORIZATION OF THE NATIONAL EARTHQUAKE HAZARDS REDUCTION ACT OF 1977

THURSDAY, MARCH 11, 1982

U.S. SENATE, COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION, SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE; HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE, AND TECHNOLOGY, SUBCOMMITTEE ON SCIENCE, RESEARCH AND TECHNOLOGY,
Washington, D.C.

The subcommittees met, pursuant to notice, at 10:15 a.m., in room 235 Russell Senate Office Building, Hon. Doug Walgren (chairman of the House Subcommittee on Science, Research and Technology) presiding.

OPENING STATEMENT BY REPRESENTATIVE WALGREN

Mr. WALGREN. If I could call us to order, I want to express at the outset my appreciation for the hospitality of the Senate Subcommittee on Science, Technology and Space, and particularly Senator Schmitt, for arranging joint hearings this year on the subject of FEMA.

Senator Schmitt will be here shortly, but he was unavoidably involved. We do appreciate his hospitality and interest and I think that the two committees, working together, will certainly accomplish more than we if we each had our separate hearings and then reconciled our opinions.

The hearings today on reauthorization of the National Earthquake Hazards Reduction Act of 1977, as I said, are being held jointly by the House Subcommittee on Science, Research and Technology, which I have the privilege to chair, and the Senate Subcommittee on Science, Technology and Space, chaired by Senator Schmitt. The fact that these hearings are being held jointly reflects the strong interest and the concern of Members of Congress in this Act.

The Earthquake Hazards Reduction Act was passed in 1977 because of the truth recognized in the Congress that earthquake hazard mitigation is a wise national investment rather than a matter of concern to limited parts of the United States.

Although earthquake hazards are popularly associated with California, in fact all or portions of 39 States are at risk. Within these boundaries live 70 million people. The risks to life and property are as great now as when the bill was passed, and the need for a coordinated national approach is equally great. Although the number of significant earthquakes in the recent past has not been large, this does not affect the need for a program in this area.

Indeed, the very infrequency of catastrophic events such as earthquakes tends to produce an attitude of neglect and it is the responsibility of the Congress through the implementation of this particular act to insure that that neglect does not occur. Investment in measures to warn of and reduce the effects of earthquakes can bring great savings in recovery and in costs of repair and suffering later on.

Implementation of this act is of more than unusual complexity since it involves a coordination between four Federal agencies as well as State and local governments. Each of these has a specific responsibility and specific duties and maintaining the balance between them is essential for the effective operation of the program.

We sometimes talk of the difficulty of coordinating the budgetary efforts of the various agencies that are involved and that, I am sure, is only reflective of the difficulty in coordinating the actual efforts of the various agencies that are involved.

We welcome the testimony of the agency representatives and are anxious to hear their views on how well the complex interagency coordination is working. This coordination of research and development, coupled to dissemination and implementation procedures involving State and local governments, is the principal responsibility of FEMA. Although the money appropriated for this purpose is negligible in the context of the overall Federal budget, its importance in dealing with a serious threat to life and property cannot be overestimated.

I would like also to welcome a distinguished group of outside witnesses, who I hope can provide us with some insights into the effectiveness of the program and its history.

I would particularly like to express my appreciation to Dr. Charles Thiel, who was formerly with FEMA and is now in the private sector. Dr. Thiel testified before the committee last year and we are very pleased to welcome him back again.

With that, I would like to recognize Congressman George Brown, who has had a very special interest in this program since its inception, for any opening statement he might like to make.

Mr. Brown.

OPENING STATEMENT BY REPRESENTATIVE BROWN

Mr. BROWN. Thank you, Mr. Chairman.

The success of the Earthquake Hazards Reduction Act is dependent on a properly designed and coordinated network of a number of agencies integrated with State and local efforts. We will be hearing from representatives of the several Federal agencies today, as well as representatives of both State and local governments and the private sector. I look forward to hearing their views on the successes and failures they have experienced from their respective roles in the implementation of the act.

It is no secret that in my part of the country we run an extremely high risk of experiencing a major earthquake in the next 30 years. I might even be so parochial as to add that this was a significant factor in my initial interest in the Earthquake Hazards Reduction Act.

But as the members of these two subcommittees know, and as the background materials for these hearings clearly indicate, earthquakes do pose a significant hazard in a majority of the States of the Union. Of course, it is our contention that a major earthquake in southern California would have a significant adverse impact upon the rest of the Nation as well. Some might doubt that.

Providing for the safety of communities and individuals at risk from earthquakes in many ways entails the same kind of preparation and certainly the same kind of post-disaster work that is necessary in other catastrophic occurrences. FEMA has the mandate to coordinate Federal emergency and civil preparedness activities, and has specifically been made the lead agency for the earthquake program.

I might say that in view of the problems which have been experienced in terms of local reaction to significant civil defense preparation, it might well be that a significant effort in the field of earthquake preparation and recovery from a major disaster might be a much more effective strategy in upgrading the total preparedness of this country than pursuing some of the courses that we have been pursuing.

An excellent example of coordinated Federal, State, and local efforts in the area of earthquake preparedness which can be used as a prototype for other earthquake programs as well as general emergency preparedness is the southern California Earthquake preparedness program. This joint effort involves funding and active participation from the State of California, FEMA and local government. I am looking forward to hearing more about that in connection with this hearing.

Mr. Chairman, the key to a successful program is leadership and cooperation. I look forward to the testimony today for evidence of effective leadership and cooperation in the implementation of this act. Thank you very much.

Mr. **Walgren**. Thank you, Mr. Brown. Other opening statements? Mr. Shamansky?

Mr. **Shamansky**. Thank you, Mr. Chairman. I would just like to note that the first experience I ever had with an earthquake in central Ohio was the summer of, I think, 1980. It has a tendency to concentrate the mind wonderfully, I think the phrase is. I always thought an earthquake was something that they had in California along with other exotic things and in movies, but not in reality. So I experienced my first tremor from an earthquake in that year and so, therefore, that has a tendency to heighten my interest in this field.

Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Shamansky. Mr. Dymally.

Mr. **Dymally**. Mr. Chairman, like all of the Californians, I am opposed to earthquakes.

Mr. **Walgren**. Well, as somebody who moved out of California one time just because of the earthquakes, I guess I have shown my true colors.

The first witness today, representing the Government effort in this area, Mr. Lee Thomas, Associate Director for State and Local

Programs and Support from the Federal Emergency Management Agency.

STATEMENT OF LEE M. THOMAS, ASSOCIATE DIRECTOR, STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY

Mr. **THOMAS**. Thank you, Mr. Chairman. Gentlemen, I appreciate the opportunity to be with you today.

Mr. **WALGREN**. Let me say at the outset that your written statement will, as a matter of course, be made part of the record. Please feel free to summarize or communicate as best you can or feel most effective. We are pleased that you are here and we welcome you to the committees.

Mr. **THOMAS**. Thank you, sir. Then I will, since you have the written testimony, attempt to highlight it, instead of going through it verbatim.

Again, I appreciate the opportunity to be here on behalf of FEMA and our Director, Louis O. Giuffrida, who was a California resident prior to coming to Washington. I can assure you that he has brought with him a great concern about the earthquake situation himself.

Overall, FEMA, as the lead agency for the earthquake hazards reduction program, has moved forward in a number of directions. In this program, I might add, there has been a considerable improvement in the coordination between FEMA and the primary Federal agencies that you will hear from today—USGS, National Science Foundation, National Bureau of Standards.

There are other Federal agencies that are obviously actively involved in the earthquake hazards reduction program, but I think those three, in addition to FEMA, are the ones that are taking a major lead as far as implementation of this program is concerned.

You will hear in detail from each of those other agencies, so I certainly will not attempt to talk about the program from their point of view. We see them as major partners with us in implementing this program and I might add I believe we have excellent working relationships with them.

In addition to those agencies we have worked closely with the Department of Defense, the Nuclear Regulatory Commission, Veterans Administration, and other Federal agencies as we have proceeded with implementation of this particular program.

I would like to mention briefly the reorganization of FEMA that occurred over the last several months that brought together the majority of the programs in field operations into one unit in the agency. We have moved all the earthquake hazard reduction program responsibilities into the directorate that I am responsible for. This realinement insures that there is a closely coordinated effort between the earthquake hazards reduction program and the other programs that we have in the agency for providing assistance to State and local units of government including the coordination of emergency response efforts among Federal agencies.

This realinement is a major step forward, particularly in the area of an integrated multihazard approach. It complements the objectives of the Earthquake Hazards Reduction Act and allows us to take the objectives of that act and insure that they become a part of our other forms of financial assistance, as Congressman Brown mentioned, such as our civil defense initiatives and additionally our responsibilities in the areas of disaster relief and overall natural hazard response planning. We have incorporated and are incorporating the objectives of the earthquake hazards reduction program into each of these other programs to insure that we have a comprehensive approach to the problems at the State and local level.

But specifically, the responsibilities that FEMA has as the lead agency break down into four categories. First is coordination of program activities as far as Federal agencies and State and local agencies are concerned. We have done a couple of things in that regard.

First, we have established, at the Federal level a formal interagency coordinating committee for the national earthquake hazards reduction program. That committee meets on a regular basis or on call. We plan to have three or four meetings a year. We have established a charter for the committee and the committee is moving forward at updating the implementation plan, particularly as it relates to a 5-year program plan for the earthquake hazards reduction program.

Second, I would like to mention that as far as coordination of Federal effort is concerned, we have incorporated preparedness earthquake planning as a major component of the administration's new initiative on emergency mobilization.

Third, earthquake preparedness planning, as it relates to State and local units of government, is a major activity that FEMA carries out jointly with the other agencies that I have mentioned. I will talk a little more specifically about some of those projects in a moment.

Also, we are moving to improve the coordination of the Federal response to a declared emergency or disaster, specifically as it relates to earthquakes. In this regard, activities in the past have largely concentrated on insuring that there was a coordinated Federal response plan, oriented toward specific locations of the country, particularly the California area. One of the improvements that we are making in FEMA is to insure that there is a national plan for coordinating the Federal response to a catastrophic earthquake wherever it may occur. We are particularly concerned about insuring that policies and procedures are in place in each of the Federal agencies that will need to support State and local government in any response to an earthquake.

Finally, I want to stress our activities in the area of improved seismic safety in construction, an area where I feel significant progress has been made over the past several years. I am particularly interested in pursuing the development of better earthquake design standards and practices.

It is a project that the National Bureau of Standards, I am sure, will discuss with you in more detail. We want to see that the standards that have been developed are adopted by both the private and Federal sectors; before they can be made available, however, we need to test their engineering feasibility and cost impact by trial designs this year and next year. Then we will be in a position to

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encourage their incorporation into the building practices of Federal agencies as well as private entities. I will talk a little more specifically in a minute about how we hope to do that.

But first, let me tell you about some of the progress we have made in earthquake preparedness for specific areas. The southern California earthquake preparedness project is one project that we believe has been a major initiative of the agency and the State of California. As has already been mentioned, it is a joint project, a Federal, State, and local cooperative effort. We believe it will result in major products and processes that can be used not only in California but also transferred to other portions of the country that have been designated high seismic hazard areas.

As I have looked at that project since I came to FEMA and as I have discussed it with both staff members from California as well as staff members in FEMA, I have been particularly impressed with the progress that is being made and the progress we anticipate being made this year. It is one where we have provided a significant amount of financial support to match that of the State of California. We anticipate continued financial support this year and hopefully next year to insure that the objectives and products that have been identified by that group in California will be completed and then applied.

You will hear from local representatives from California on this subject. I am sure they will be talking to you more specifically about some of the work of that project, so I will not go into a lot of detail.

One of the things that I think is particularly interesting, though, is that it is a local level-up planning process. It has heavy involvement by the local units of government. I think that is particularly important as they develop specific plans, both for responding to an earthquake and responding to the prediction of an earthquake. I also think that it will be particularly useful not only in that area, but in other areas of the country. We look on it as our highest priority as far as a local project is concerned that will pay off nationally.

As far as the remainder of California is concerned, beyond the southern California project, we do have an active effort in the San Francisco Bay Area managed by our regional office in San Francisco. It will update a response plan which was developed for the bay area and insure that it is a generic plan that is available for Federal agency response to support State and local government throughout California.

So the efforts in southern California should not be looked at as our only effort in California. We have additional efforts managed by our regional office with State cooperation that are comprehensive as far as the seismic problem in the California area is concerned.

We also have a vulnerability analysis project in the central United States. There is a seven-State area which has been designated as a particularly high hazard area in the central United States. We have a vulnerability analysis project underway that will continue this year, and we anticipate will be expanded (if resources are available) in fiscal year 1983, probably along the lines of the southern California project. We expect to be able to utilize a number of the products that have come out of the southern California project in those seven States. We also have activities in other high hazard areas of the country, such as the Salt Lake City area, the Northeast—particularly in the Boston community, as well as Alaska and Hawaii.

In the area of seismic safety for construction, these past 2 years, I think, have seen a considerable effort in developing improving seismic standards which can be utilized in the design and construction techniques of buildings. This effort has been conducted both through the Building Seismic Safety Council, which represents the private sector, and the Interagency Committee on Seismic Safety in Construction, which is representative of the Federal agencies.

There has been quite an effort over the last several years to develop standards which can be incorporated into building practices in the public sector and private sector. It is an area, from a mitigation point of view, that I am particularly interested in seeing us move forward this year, in fiscal year 1982.

So, with some of the resources that Congress approved for our agency for this year, we have begun negotiations with the Building Seismic Safety Council. They are to examine for us the design techniques incorporating the improved seismic standards that have been developed and, through trial designs in several cities around the country, determine whether they are economically feasible and sound from the engineering standpoint. Since all segments of the building industry are working with us. The results should be acceptable to both building trades and units of government. Through this concensus approach, seismic safety designs will be incorporated in buildings in high hazard areas. So it is an important project that we intend to start this year.

In summary I would say that as I came into FEMA 8 or 9 months ago and again over the past months, I have had an opportunity to take a hard look at the earthquake hazards reduction program as it relates to the objectives of the Earthquake Hazards Reduction Act. As a result, I feel that a considerable amount of progress has been made.

As you have already mentioned, Dr. Thiel will testify later in this hearing. I think he deserves a considerable amount of credit as far as the progress that has been made, particularly in FEMA. On the other hand there is a considerable amount of progress still to be achieved.

As Congress did in 1977, I certainly recognize that earthquake preparedness is a major area of concern in this country. The progress that has been made over the last 2 years gives us a good foundation to proceed and actually apply the knowledge that we have acquired. Again, I appreciate the opportunity to be with you and I will be pleased to try to respond to any of your questions.

[The statement follows:]

STATEMENT OF LEE M. THOMAS, ASSOCIATE DIRECTOR, STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY

It is my pleasure to appear before your subcommittees on behalf of Louis O. Giuffrida, Director of the Federal Emergency Management Agency (FEMA) to present the Agency's views on the national earthquake hazards reduction program, FEMA's lead agency role for the program, and the reauthorization of the Earthquake Hazard Reduction Act of 1977.

The national earthquake hazards reduction program (NEHRP) represents the culmination of many years of concerted action on the part of both the legislative and the executive branches. It was created by the Earthquake Reduction Act of 1977 (Public Law 95-124), as amended, and the resultant program transmitted by the President of the United States to the Congress on June 22, 1978. The leadership and coordination role for the NEHRP was at first placed in the Office of Science and Technology Policy of the Executive Office of the President and then transferred to FEMA by the President's Reorganization Plan No. 3 of 1978 and Executive Orders 12127 and 12148.

The Federal agencies participating in this program are numerous. You will hear testimony from the major participants: The United States Geological Survey (USGS), the National Science Foundation (NSF), and the National Bureau of Standards (NBS).

USGS conducts and sponsors research on (1) the nature of earthquakes, including the physical processes controlling ground shaking, ground failure, surface faulting, and tectonic deformation; (2) earthquake prediction; and (3) induced seismicity. In addition, USGS delineates and evaluates geologic hazards, prepares seismic risk maps; evaluates earthquake predictions; provides data on earthquakes and related occurrences to all interested parties; and sponsors a vigorous program of outreach to Federal, State, and local governments and many elements in the private sector.

NSF sponsors research on earthquake processes and phenomena in its geophysics program and on earthquake engineering and socioeconomic implications of earthquakes in its civil and environmental engineering program. The geophysics program covers the basic disciplines of seismology, gravity, geodesy, magnetism, Earth currents, and heat flow; the structure and physical properties of the Earth's interior, the plates making up the Earth's lithosphere, and the behavior of natural materials at high pressures and temperatures are examined. Fundamental earthquake studies are conducted to improve the understanding of the natural phenomena involved in an earthquake and provide the knowledge necessary for the potential prediction of earthquakes and destructive ground motion. In NSF's division of civil and environmental engineering, research is supported in the fields of earthquake engineering, architecture, and urban planning. Such research provides information on the nature and effects of destructive ground shaking, as well as practical methods of analysis, design, and planning for safe and economical earthquake countermeasures (applicable to both existing and planned structures). NSF's societal response program supports research of the responses of individuals, organizations, and communities to earthquakes and related hazards to (1) develop knowledge on the socioeconomic aspects of hazard mitigation; (2) increase the knowledge base about hazard preparedness; (3) improve the understanding of disaster impacts, responses, and recovery; and (4) provide a basis for improving the dissemination and utilization of earthquake hazard information by decision-makers and the public.

NBS contributes research on performance criteria and supporting measurement technology for earthquake-resistant construction. It also provides technical assistance to other organizations in the development of design and construction provisions to reduce earthquake hazards in new and existing buildings.

Other Federal agencies participating in the program include the Departments of Defense, Transportation, Housing and Urban Development; the Veterans' Administration; the National Oceanic and Atmospheric Administration; the General Services Administration; and the Nuclear Regulatory Commission.

Without FEMA, NEHRP activities enjoy a high priority. At the national office, a recent realignment has resulted in the centralization of all earthquake responsibilities in the Office of State and Local Programs and support that I head. As a result, I am able to call on an interdisciplinary staff with expertise in such diverse areas as response and recovery assistance, geology, hazard mitigation, law, engineering, planning economics and other complementary fields. Further, in each of our ten regions there are persons assigned to earthquake-related functions. In this organizational arrangement I am now responsible for the full spectrum of NEHRP activities; from research and applications of its results to preparedness for, mitigation of response to, and recovery from damaging earthquakes.

Another even more important consideration to note is the fact that as the Associate Director for State and Local Problems and Support, I also have responsibility for other emergency management assistance programs for State and local units of government. That includes the disaster assistance program as authorized under the Disaster Relief Act of 1974, components of the civil defense program, and in full range of other natural and technological hazards programs that provide assistance at the State and local level.

This organizational arrangement provides me an opportunity to ensure an integrated and a multihazard approach to emergency management within our Agency across all hazards, including earthquakes. It gives us an opportunity within FEMA to build the objectives of each program into the delivery mechanisms of those programs, as we provide financial, planning, or technical assistance at a State and local level.

In specific terms, earthquake considerations will be part of State and local programs dealing with all Emergency Management activities. At that level, available earthquake resources will be bolstered by resources drawn from civil defense, disaster assistance, flood plain management and hazardous materials management in an effectively coordinated manner. This is the first time that a comprehensive emergency management thrust is under the same organizational structure.

Now I want to return to the NEHRP. Under this program, FEMA has four specific responsibilities: (1) Coordination of all program activities; (2) earthquake preparedness planning; (3) coordination of Federal activities in response to a declared earthquake disaster or emergency; and (4) development of improved seismic construction codes, standards, and practices.

COORDINATION OF PROGRAM ACTIVITIES

Coordination of program activities is designed to ensure that all segments of the program in both the public and private sector work harmoniously toward the objective of reducing the risks to life and property caused by earthquakes in the Nation. In addition to the Federal agencies that I have mentioned, more than 39 States and countless counties and municipalities with a population of over 70 million people comprise the public sector. The academic community, voluntary agencies, professional groups, industry and commerce, and the general public make up the private sector.

Until recently, we used long-standing but informal means of coordination within the Federal community. Now there is a formal mechanism—the Interagency Coordination Committee of the National Earthquake Hazards Reduction Program. The objective of the committee is to ensure that all segments of the program work harmoniously toward reducing the earthquake hazards in this country. A charter for this committee has been prepared and presented for comments to participant agencies. Three to four meetings of the committee per year are anticipated, with additional sessions called to deal with special problems. The last meeting was held in February and the next one is scheduled for May.

The President has given FEMA the mandate to coordinate Federal activities across the full spectrum of emergencies from nuclear war to nuclear weapons accidents, nuclear plant incidents, hazardous materials accidents, and natural disasters. It makes sense that FEMA also coordinate the activities of the earthquake hazards reduction program. Our improved organizational structure, our comprehensive emergency management approach, and our operational experience in multi-hazard emergency management, give assurance of our capability to discharge this responsibility in the future to the full satisfaction of the Congress.

EARTHQUAKE PREPAREDNESS PLANNING

Because of the extent and nature of the damage that large earthquakes can cause when they occur in heavily populated and industrialized areas, specialized planning is needed to respond to them and to provide recovery assistance to the stricken localities (after a Presidential declaration). This assistance is supplemental to that furnished by local and state authorities. Going back a decade, the Office of Emergency Preparedness initiated an effort to satisfy this need. Today this effort continues in a significantly expanded form with the active participation of some 12 States, a large number of counties and municipalities, all major Federal departments, voluntary agencies, the research community, and the design and construction professions.

Before I leave this topic, let me mention one more significant effort in which FEMA is involved. Last December, the President created the Emergency Mobilization Preparedness Board (EMPB) to address the task of "development of a credible and effective capability to harness the mobilization potential of America in support of the armed forces, while meeting the needs of the national economy and other civil emergency preparedness requirements." Established by presidential directive in December 1981, the board is headed by the Assistant to the President for National Security Affairs. The membership includes top-level administrators of all major Federal departments and senior White House staff. FEMA provides the secretariat for the EMPB. One of the EMPB working groups deals with the effects of a catastrophic earthquake on the economy of California and the Nation and on military operational capabilities. FEMA has assigned two members to this group and will participate actively in its studies and assessments, as it did when an ad hoc panel of the National Security Council undertook an initial examination of the same problem area in the summer of 1980.

COORDINATION OF FEDERAL RESPONSE TO A DECLARED EMERGENCY OR DISASTER

Federal earthquake response plans have been completed and exercised for the Puget Sound area in Washington and for Salt Lake City, Utah. Considerable Federal planning has also taken place for responding to an earthquake in California. The emphasis in this planning has been on providing support in the initial emergency phase (first few days) after a disaster. This support includes search and rescue, medical support and evacuation, mortuary assistance, mass feeding and shelter, and communications. Resources recently have been directed toward formulation of a national plan for responding to earthquakes. Through coordination with Federal agencies at the national level, major requirements will be identified and missions for planning and developing delivery capability will be assigned. These assignments will be adapted at the regional and local Federal Government levels to deal with specific requirements unique to the area. this planning will be a continuing process with new requirements continuously identified by tests and exercises, resources requirements updated, and close relationships established with all FEMA regions and affected jurisdictions. It will give me the mechanism for ensuring a comprehensive response to any damaging earthquake from both the national and regional Federal staffs. In formulating this plan, all hazard considerations will be included.

IMPROVED SEISMIC SAFETY IN CONSTRUCTION

In establishing the NEHRP, the Congress specifically mandated "the development of technologically and economically feasible design and construction methods and procedures to make new and existing structures, in areas of seismic risk, earthquake resistant. . .". FEMA has been pursuing the fulfillment of this mandate in a two-pronged, coordinated manner.

In the private sector, the development of improved model seismic design provisions suitable for incorporation into local building codes was hindered historically by the lack of a forum where the many diverse elements of the construction industry could discuss and resolve their many differences. The creation of the Building Seismic Safety Council (BSSC) under the National Institute for Building sciences (NIBS) now provides such a forum—with FEMA funding and NBS technical guidance and assistance. BSSC has a membership of some 60 organizations, representing hundreds of thousands of individuals from private and public entities. It has been analyzing and resolving the complex, technical, social, economic and public and provate jurisdictional issues of building regulations to facilitate the development and use of consensus codes, standards, and practices. This is one significant new initiative that in the long term will help local authorities to mitigate earthquake hazards.

A parallel effort is being conducted at the Federal level, where some 35 different Federal agencies that have responsibility for construction have been using different seismic measures in the design of their many buildings. To standardize these measures, and to incorporate the results of recent scientific and technical advances, (thus setting an example for the private sector), FEMA formed the Interagency Committee on Seismic Safety in Construction (ICSSC) in 1978. One hundered fifty persons from 17 Federal departments and agencies participate in the work of the ICSSC, which is organized into ten subcommittees and two task groups. As one product example, ICSSC developed and published a draft seismic standard for new Federal buildings in 1981. The standard was disseminated last fall to the relevant agencies for their use in design, contract administration, and quality control. after the testing of these standards and any necessary revisions, they will be recommended for Federal use.

These are the four areas of FEMA responsibility in the NEHRP. Our progress to date is presented in the report to the Congress on the NEHRP and the companion publication containing detailed technical information. Both have been made available to you very recently. Now I want to identify the major thrusts of our planned activities in fiscal year 1983:

SCEPP

The most extensive effort in earthquake preparedness planning at present is going on in the five counties of the Los Angeles Metropolitan Area (San Bernardino, Riverside, Orange, Ventura, and Los Angeles). Here a joint State of California-Federal Government activity (SCEPP as it is known, or Southern California Earthquake Preparedness Project) involves the participation of the general public, neighborhood groups, industries, voluntary agencies, and local authorities in preparing for both a predicted and an unpredicted large-magnitude earthquake. (This is the area, you will recall, where scientists estimate that there is a greater than 50 percent chance that a magnitude 8+ earthquake will occur within 30 years.) SCEPP's goal is to stimulate preparedness for predicted or unpredicted catastrophic earthquakes within the five-county area.

SCEPP's objectives are to develop:

A propotypical planning process for earthquake hazard reduction;
A prediction warning/communication system;
A model comprehensive regional management system;
A uniform terminology for expressing earthquake potential;
Model education/information approaches and materials.

Plans and processes developed by SCEPP will be transferred to other high-risk regions throughout the Nation, to the extent possible.

Several other aspects of SCEPP are unique. Through planning partner arrangements negotiated with selected public and private jurisdictions within the five-county area, SCEPP's prototype plans are being developed from the local level up, involving officials in many agencies. The process and plans thus respond to local needs. SCEPP's approach represents a major departure from earlier preparedness planning approaches and concepts. SCEPP, for example, operates under the executive authority of the California Seismic Safety Commission and under the guidance of a 21-member policy advisory board. The board is composed of representatives of public and private agencies within the Los Angeles Metropolitan Area who oversee SCEPP's activities and act as an outreach group into the community to promote SCEPP activities. SCEPP also emphasizes coordination with ongoing agencies such as the California Office of Emergency Services, the USGS, the American Red Cross, the California Division of Mines and Geology, the State Task Force on Earthquake Preparedness, FEMA, regional government associations, private industry, the scientific community, and the schools. Further, through planning partner arrangements, SCEPP is facilitating the development of prototype plans for how an earthquake prediction would be validated and communicated to public and private officials, how the region would respond to such a prediction, and how to minimize negative impacts of an earthquake warning.

SCEPP accomplishments and activities to be completed in 1983 are:

Planning partner agreements.—One is already in effect with San Bernardino County; another with the city of Los Angeles has been negotiated and is currently being reviewed by the Los Angeles City Council; several with private sector entities (e.g., major financial institutions, small businesses, and community-based institutions) are planned for fiscal year 1982;

Prototype plans.—These cover earthquake prediction warning/communications system; earthquake prediction response; response to unpredicted catastrophic earthquakes; and guidelines for short-term and long-term recovery. These are expected to be completed in calendar 1983.

Prototype planning process.—A careful documentation of the processes used in developing these plans will be also scheduled for completion in 1983 to facilitate evaluation of SCEPP and its transferability to high-risk, high-seismicity areas.

Model regional earthquake responses management system.—The system will identify strategies and procedures for the management of resources in responding to large-magnitude earthquakes. This regional resources management system will address the centralization of emergency management data and information, the integration of the comprehensive prototype planning model developed as part of this effort, a set of intergovernmental coordinating procedures, and priorities for the allocation of resources. Regional integration mechanisms will be developed. This effort is being carried out in coordination with a statewide task force on earthquake preparedness established by Governor Brown in February 1981.

Earthquake prediction warning/communication system.—A standard terminology for expressing earthquake potential has been developed along with the guidelines for the warning period itself and strategies for a public education campaign. This system will be refined in extensive discussions with affected entities and, if found suitable, will be recommended for adoption by appropriate State and Federal agencies.

Public information and education program.—SCEPP edcuation/information staff has so far gathered and inventoried available public information and education material and identified the need for specialized material on prediction and material which addresses the needs of special groups within the general population (non-English-speaking, handicapped, apartment dwellers, and other groups). With inputs from all other project activities, information and educational products will be prepared for all target audiences, including school populations, the media, community groups, public agencies, businesses, neighborhoods, families, and individuals. One example of this activity is the development of a comprehensive school curriculum for earthquake preparedness and model school disaster plans through the San Bernardino planning partner arrangement.

SCEPP is also reviewing international prediction/preparedness efforts, particularly the Japanese program, for possible transferability to our efforts.

REMAINDER OF CALIFORNIA

Currently, the San Francisco Bay Area Federal Response Plan is being converted to a generic earthquake response plan for all of California. Due for publication in 1982, the generic plan will reflect revised and expanded mission assignments to tasked Federal agencies. An opening draft is planned to be in place by June 1, 1982, in time to test in a joint Federal/State earthquake preparedness exercise in midsummer. SCEPP materials will be examined for applicability to the San Francisco Bay Area and appropriate initiatives started in fiscal year 1983.

CENTRAL UNITED STATES

There is now underway in this area an effort to determine the earthquake vulnerability of 128 counties in seven States of the Midwest and Southeast located within an earthquake intensity zone of VIII or greater on the modified Mercalli scale. Data collection is currently underway in six pilot cities—Poplar Bluff, Missouri; Memphis, Tennessee; Little Rock, Arkansas; Carbondale, Illinois; Paducah, Kentucky; and Evansville, Indiana. Lessons learned and methodology developed during this effort will be used in selecting approaches for data collection in the remainder of the affected area, expected to be completed by the end of FY-82. The data will then by analyzed, damage and casualty estimates made, and data on liquidation and flooding developed. The resultant assessment of deaths, injuries, homeless, and damage to critical facilities will be used in planning response by all elements of government to a catastrophic earthquake of the magnitude of those of 1811-1812 on the New Madrid Fault.

As resources become available and SCEPP material is completed and evaluated, there is a probability that a SCEPP-like project will be established in the out-years in the Central United States with somewhat similar objectives. The spadework has already started with strong support from USGS's technical and outreach activities.

OTHER AREAS

In addition to these three priority areas—Los Angeles Metropolitan Area, the San Francisco Bay Area, and the Central United States—earthquake preparedness planning is now underway in five other urban areas, addressing specific problems created by unique geographic or geologic considerations: Boston, Salt Lake City, Honolulu, Puget Sound, and Anchorage. These are expected to be completed in fiscal year 1983. Preparedness planning for Charleston, Buffalo-Rochester, San Diego, and Puerto Rico will be undertaken in the coming years as resources become available and as the accumulated experience in other areas is ready to be transferred.

BSSC

Tentative seismic provisions based on a broad consensus of the construction industry have been prepared. They are now ready to be subjected to a process of trial designs to determine their engineering feasibility and economic viability. FEMA expects to fund BSSC during this fiscal year—negotiations should start within the next 45 days—to complete plans for trial designs and test some dozen building types in two cities (probably Memphis and Los Angeles). If the Congress makes resources available, we plan to complete the trial designs in the other five cities—Los Angeles, Seattle, Phoenix, Chicago and Minneapolis—in fiscal year 1983. After the results of the designs are evaluated, and any revisions in the provisions are made, BSCC will work in fiscal year 1984 and later to encourage the use of these improved seismic measures as a resource for voluntary updating of model codes and national standards.

ICSSC

FEMA plans to increase the level of activity of this very significant committee in fiscal year 1983. Leadership and membership of subcommittees will be updated, accelerated milestones for ongoing efforts established, and a small amount of funding for publication and dissemination of studies will be provided. Above all, however, FEMA plans to exert its leadership among Federal agencies to expedite trial designs of the draft seismic standard for Federal buildings to which I referred earlier.

Mr. Chairman, I have attempted to convey FEMA's position on its leadership role in the NEHRP and its major accomplishments and thrusts in fiscal year 1983. Representatives of other participants in the NEHRP will provide you with additional information, and, as I have said earlier, a comprehensive examination of NEHRP activities has recently been completed. The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) under which these earthquake-related activities are being conducted, is a wise, comprehensive, and far-sighted law. Its objectives remain sound and it has served its purposes well since it was passed.

Achievements to date have been notable and numerous. We are continuing to make progress in our understanding of the basic sciences and phenomenology of earthquakes. Similarly, we are continuing to improve our ability to design structures in ways that minimize damage and casualties caused by tremors. Increasingly, this knowledge is being made available to practitioners in a form useful for their purposes. Further, the knowledge is being incorporated in seismic standards for ultimate use by Federal agencies and voluntary adoption by local regulatory agencies. Also, an extensive program of seismic response preparedness in areas of high and moderate risk is progressing.

Nevertheless, significant scientific, technical, and managerial problems remain for the coming years. Basic investigation of seismological and geological phenomena must be continued intensively, and the gathering of data on earthquakes all over the world needs to be strongly supported. These data and new scientific knowledge need to be applied to the still elusive problem of earthquake prediction, on which a new set of preparedness measures could be based. Further, the efforts to improve seismic codes, standards, and practices in both the private and public sectors need to be pursued with greater vigor than in the past. These tasks require resources greater than have been made available to the NEHRP so far, and on a more steady, dependable basis. Managerial problems also exist and are being addressed. The NEHRP, for example, needs a well-articulated, coherent 5-year program plan, with measurable milestones. The preparation of this plan has become a priority item. Also, coordination among the Federal agencies requires continuing effort.

There are strong grounds, therefore, to recommend that the Earthquake Hazard Reduction Act of 1977 be reauthorized for two years with its existing substantive provisions intact.

Thank you, Mr. Chairman. I am ready to try to answer any questions you may have.

[The following information was subsequently received for the record:]

Federal Emergency Management Agency,
Washington, D.C., April 13, 1982.

Hon. Harrison H. Schmitt,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

Dear Senator Schmitt: This is in response to your March 19, 1982 letter requesting the Federal Emergency Management Agency's (FEMA) response to questions on the Agency's testimony on the National Earthquake Hazards Reduction Act. Set forth below, in the order asked, are the questions and FEMA responses.

Question. Public Law 97-472 directs FEMA to compile a written program plan for the National Earthquake Hazards Reduction Program by September 30, 1981, and to submit the plan to the Congress. The plan has not been submitted. When will the plan be submitted? Will FEMA implement its part of the plan in fiscal year 1982? How will FEMA assure implementation of the plan in other agencies? Will the plan cover utilization of research-derived knowledge, an area of concern to the Congress, to State and local governments and to the private sector?

Answer. Development of a five year program plan as required by the National Earthquake Hazards Reduction Program is underway. A draft of the plan will be ready for review by August 1982 and the plan will be submitted to the Congress by December 30, 1982. FEMA is implementing in fiscal year 1982 its part of the National Earthquake Hazards Reduction Program (NEHRP) as spelled out by the Act. FEMA's activities will be incorporated in the plan submitted to the Congress. The mechanism for implementation of the plan is the Interagency Coordination Committee of the NEHRP which is chaired by FEMA and which meets formally at least once every quarter. The activities of this committee were discussed on page 5 of my testimony. The next meeting of this committee is scheduled for May 6th. The five year program plan will include utilization of research developed on reducing the adverse effects of earthquakes on lives and property.

Question. FEMA has been viewed by many in the Congress as giving low priority to earthquake activities—especially those intended to minimize hazards (as opposed to emergency response after an earthquake). What specific actions will FEMA take in the rest of fiscal year 1982 and in fiscal year 1983 to convince the Congress that FEMA is giving priority attention to earthquakes? What milestones are appropriate for charting real accomplishments and substantial progress in calendar year 1982?

Answer. As discussed in my testimony, FEMA has given a high priority to the NEHRP. A realignment within FEMA has centralized all earthquake responsibilities in the Office of State and Local Programs and Support for which I am the Associate Director. As a result of this realignment, I am able to use an interdisciplinary staff with diverse expertise in geology, response and recovery assistance, hazard mitigation, law, engineering, planning, economics and other complementary fields. My office is, during fiscal year 1982, beginning the development of a National Earthquake Response Plan to be used in the event of a major earthquake catastrophe. In addition, we are initiating the trial building designs by the Building Seismic Safety Council (BSSC) for improved Seismic construction provisions; revitalizing the Interagency Committee on Seismic Safety in Construction; and applying research for the use of State and local governments.

Question. Although FEMA has extensive earthquake-related responsibilities at the national level as well as in the regions, only 8 FEMA professional staff members have been assigned to these activities in recent years. Will FEMA increase the number of staff assigned to earthquake activities for the rest of fiscal year 1982? For fiscal year 1983?

Answer. We are currently reviewing the number of staff assigned to the earthquake activities in fiscal year 1982 to determine if there are sufficient resources available to meet our goals. As a result of the realignment, we have more resources working on the NEHRP than previously.

Question. In the fiscal year 1982 House Committee report, concerns were expressed (page 4) as to whether FEMA had made progress in establishing a multihazard approach to its responsibilities. What progress has been made?

Answer. As a result of the realignment of FEMA's programs, we have incorporated into the Directorate of State and Local Programs and Support all the programs relating to natural and technological hazards. We are incorporating the earthquake program and the other natural hazard and technological hazard programs into a comprehensive emergency management program for state and local governments.

Question. Also in the fiscal year 1982 report, the Committee requested FEMA to submit a report in private sector involvement in the earthquake Hazards Reduction Program. Has the report been submitted? What has been the private sector involvement outside of SCEPP?

Answer. In addition to the Southern California Earthquake Preparedness Project (SCEPP), FEMA has been involved with the Building Seismic Safety Council (BSSC), a group of 60 organizations representing thousands of individuals engaged in all segments of the construction industry. FEMA continues to encourage private sector involvement in the NEHRP. Please refer to page 7 of the enclosed copy of "The National Earthquake Hazards Reduction Program, A Report to the Congress (Fiscal Year 1981)." Please let me know if you wish to receive a separate report on the private sector involvement in the NEHRP.

Question. What project-oriented initiatives are under way (apart from SCEPP)?

Answer. There are several initiatives underway: (1) preparation of intensity maps, and estimates of casualties and damage to critical facilities and lifelines in six pilot cities in the Central United States, in Boston, and In Oahu, Hawaii; (2) contingency response plans for four counties along the Wasatch fault in Utah, for four counties in the Puget Sound area, and for the City of Anchorage; and (3) a workshop on contingency earthquake preparedness in the Central United States in St. Louis in May 1982, a sequel to the one held in Knoxville in September 1981.

Question. In the Annual Report for fiscal year 1981, it states, "Managerial problems also exist and are being addressed. The NEHRP needs a well-articulated, coherent program plan, the preparation of which should be a priority item." What plans have been made to address these problems within the National Earthquake program?

Answer. One managerial problem was solved by centralizing all significant earthquake activities in the FEMA National Office under the Associate Director for State and Local Programs and Support. Also, the strengthening of the Interagency Coordination Committee of the NEHRP and the revitalization of the Interagency Committee on Seismic Safety in Construction are proceeding.

Question. What plans does FEMA have for earthquake contingency planning efforts in the Central United States?

Answer. For earthquake planning efforts in the Central United States, the first phase, a vulnerability analysis, is well underway. In fiscal year 1981, an interagency agreement was signed with the U.S. Geological Survey (USGS) to study possible earthquake losses in the area that will be impacted from a major earthquake near New Madrid, Missouri. Objectives of the study are as follows: (1) Estimate the magnitude and probability of earthquake occurrence; (2) estimate damaging ground motion throughout the Midwest; (3) indicate areas where liquefaction, landsliding, and flooding caused by earthquakes may occur; (4) review the estimation of damages (prepared by an engineering subcontractor); (5) provide a methodology for collection of inventory data; and (6) identify areas expected to have only minimal damage. Collection of inventory data of possible losses by FEMA staff for two of six major cities in the impacted area is near completion, with the remaining cities to be completed by the end of fiscal year 1982.

In fiscal year 1983, the vulnerability study is expected to be completed and the second phase, development of preparedness plans, will be initiated. A review of the entire planning program is presently underway to consider incorporating some of the suggestions of the FEMA/USGS-sponsored workshop on earthquake preparedness and response held last September in Knoxville, Tennessee. In May of this year, FEMA and the USGS will again cosponsor a workshop directed at enhancing the Central U.S. planning program. A major approach of the forthcoming workshop will be to review ways of transferring information from the Southern California Earthquake Preparedness Project (SCEPP) and their procedures for involving multijurisdictional governments, the general public, and private businesses into the planning process. The earthquake contingency planning effort will take several years, but major steps have already been taken and the effort is well underway

Question. Should the Earthquake Hazards Reduction Act have a single year or a multi-year authorization?

Answer. A multi-year (two-year) authorization would allow greater stability in funding and, consequently, in planning activities of the NEHRP.

Question. The authorization level for fiscal year 1982 was $5.3 million, however, your actual appropriation was $1.058 million. What activities were planned that will not get conducted because of this decrease?

Answer. It resulted basically in continuing the progress of ongoing projects with no new initiatives started. In addition funding for the National Building Standards was scaled back.

Question. Only California seems to be making substantial progress in earthquake mitigation. Yet there are a number of other areas of high seismic risk such as New Madrid, Mo.; Boston; Charleston, S.C.; Puerto Rico; Puget Sound; and the Salt Lake City area. What is needed to get substantial programs emphasizing both preparedness and emergency response underway in these areas? How long would it take to get substantial efforts underway in these areas, similar in breadth to those in California, where the State, the localities and the private sector are involved?

Answer. More emphasis is being given to mitigation measures in areas other than Southern California based on need. For example, for Northern California and the Central United States we are laying the foundations in fiscal year 1982 for an expanded effort in fiscal year 1983, if funds are made available by the Congress. In these two areas, we are talking in terms of a multi-year, substantial funding level. In addition to funds and staff, there is a need for a strong local leadership to emerge among elected and appointed officials, academicians, professionals, voluntary groups, neighborhood groups, and the general public, so that the effort has a broad support. It is now beginning in the Central U.S. and in the Charleston, S.C., area. It needs to be cultivated in other areas, starting with the definition of the hazards and an increased awareness of these hazards.

Question. What plans does FEMA have for tests, simulations, or other means of evaluating State and local earthquake migigation activities? Will any activities be evaluated in fiscal year 1982 or fiscal year 1983?

Answer. As part of FEMA's mitigation activities, which include response, a number of activities are planned for fiscal year 1982 and fiscal year 1983. In December 1981, Region IX exercised the existing Federal Response Plan for the San Francisco Bay Area, identifying functions that need improved response capabilities. These will be tested again before the end of this fiscal year, using a more demanding scenario. Region X will observe and evaluate the "table-top" exercise of Washington State's response plan this fiscal year. For fiscal year 1983, specific test and exercise plans are now being formulated. Regions IX and X will continue their test and exercise projects in the San Francisco Bay and Puget Sound areas and expand them to cover the Salt Lake City and Anchorage areas, respectively, assuming availability of funds and participation of local jurisdictions. San Bernardino County may also conduct exercises in fiscal year 1983.

Question. Most of FEMA's activities seem devoted to post-disaster response rather than hazard mitigation. Where in the National Earthquake Hazards Reduction Program is the primary responsibility for damage prevention? How is this responsibility being carried out?

Answer. The responsibility for damage prevention resides in each of the Agencies participating in the NEHRP (e.g., NSF does basic research that contributes to more seismic restrictive structures, USGS improves our capability to predict earthquakes, VA is upgrading its facilities in seismically active areas). These activities are coordinated by FEMA through the Interagency Coordination Committee of the NEHRP, as discussed in my testimony and as mentioned earlier. As for FEMA activities, over 60 percent of our available fiscal year 1982 funding will be devoted to mitigation initiatives, as contrasted to response projects.

Regarding the Interagency Committee on Seismic Safety in Construction (ICSSC) which FEMA chairs—

Question. What resources (professional staff and contract or consultant funds) will be devoted to ICSSC in fiscal year 1982 and in fiscal year 1983 by FEMA and by other agencies?

Answer. Approximately 4-5 equivalent professional staff persons will be devoted to ICSSC activities in fiscal year 1982 and about 8-10 are planned for fiscal year 1983 (assuming the requested budget funding is approved for all NEHRP agencies by the Congress). Only nominal consultant fees (less than $10,000) are expected to be devoted to ICSSC for both fiscal years.

Question. Briefly, what products are expected in calendar year 1982 from the 10 ICSSC subcommittees and how many of these products will be in finished form, ready for implementation?

Answer. We expect the following reports in finished form and ready for dissemination in 1982: (1) repair and strengthening of existing buildings; and (2) means to evaluate potential soil failures. A third report on hazard definition and design consideration of tsunami flood waves was completed in fiscal year 1981 and will be disseminated in fiscal year 1982.

Question. Would you discuss briefly the program of the Building Sciences Safety Council (BSSC) in 1981 and any plans FEMA has for working with BSSC in fiscal year 1982 and fiscal year 1983?

Answer. BSSC formulated and balloted a substantial number of refinements of the Applied Technology Council Publication ATC 3-06, Tentative Provisions for the Development of Seismic Regulations for Buildings and prepared a draft plan for trial building designs of the improved provisions. In fiscal year 1982 we expected to initiate the trial designs of buildings in Los Angeles, Seattle, Phoenix and Memphis and complete this effort in fiscal year 1983 (funding being made available by the Congress) by similar trial designs in four additional cities.

If I or my staff can be of further assistance, please do not hesitate to contact my office.

Sincerely,

LEE M. THOMAS,
Associate Director.

Mr. WALGREN. Thank you very much, Mr. Thomas.

At this point I would like to ask to join you at the table with several other witnesses from the Government, and then we will question the panel as a whole. But I did want to bring you forward first, singularly, because of your role in this effort.

Can I ask Dr. Dallas Peck, the Director of the U.S. Geological Survey, Dr. Jack Sanderson, Assistant Director for Engineering, and Dr. Francis Johnson, Assistant Director for Astronomical, Atmospheric, Earth and Ocean Science with the National Science

Foundation, and Dr. John Lyons, Director of the National Engineering Laboratory of the National Bureau of Standards to come and join Mr. Thomas at the table?

I think in the interest of time we should have these statements given sequentially. The witnesses are being given 10 minutes, and we certainly appreciate your trying to conform to that time. That will allow time for questions at the end.

Let me start and ask, next, Dr. Peck, if you would give us your statement and know that your written statement will be made part of the record. You may summarize or proceed as you feel best.

STATEMENT OF DR. DALLAS PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY

Dr. **Peck**. Thank you, Mr. Walgren. I welcome the opportunity to appear before this joint hearing to reauthorize the Earthquake Hazards Reduction Act of 1977.

The Geological Survey is now in its 5th year of participation in the national earthquake hazard reduction program. We work closely with the Federal Emergency Management Agency, the National Science Foundation, and the National Bureau of Standards in carrying out the purposes of the original act.

Our program consists of five elements which are described in some detail in the written statement I have provided for the record. Briefly, these elements are earthquake hazard and risk assessment, earthquake protection research, earthquake data and information services, induced seismicity and, finally, earthquake hazard information dissemination.

I would like to respond briefly to the three specific questions posed by Senator Schmitt in his kind invitation to appear before this joint hearing. With regard to progress in earthquake prediction, we cannot report that we have found a complete solution to this difficult problem. Our major advance and the basis of our current approach to earthquake prediction is the adoption of the concept of the seismic cycle for various regions or segments of major fault systems.

Although the strain accumulation due to relative motion between large sections or plates of the Earth's crust builds continuously, the manner in which the strain is released is cyclical and varies geographically. In this context, the question of earthquake prediction can be broken down into three parts—what are the characteristics of the seismic cycle in various seismically active regions; at which stage of the seismic cycle are we currently in in each region; and in those regions where the seismic cycle ends with a catastrophic earthquake, how do we predict this event.

In California we have identified the characteristics of the seismic cycle of four major segments of the San Andreas fault. We know that the northern and south-central segments of the fault are capable of storing enormous amounts of strain over periods of about 150 years and then releasing the strain in large, destructive earthquakes such as happened in 1906 in the north and in 1857 along the south-central part of the fault.

Although detailed geologic studies of the faults in the south-central portion of the San Andreas, which last broke in 1857, we estimate that the average recurrence rate of large earthquakes is about 145 years and that there is about a 50 percent chance of a major earthquake there in the next 30 years. Similar studies are in progress on other active faults, but we cannot yet make statements with equal confidence for those regions.

The problem of more specific or short-term predictions of major earthquakes is being addressed by making extensive field observations of geophysical and geochemical phenomena such as seismicity, Earth strain and radon concentration in ground water.

Through these observations we can establish a statistical relationship between the occurrence of the geophysical and geochemical phenomena and major earthquakes. These statistics will then be used in any given cycle to incrementally increase the probability estimates for the occurrence of a major earthquake in the region and narrow the time frame into which these estimates apply.

To provide these observations we have deployed extensive seismometer networks, established 25 geodedic strain monitoring networks, each containing several hundred survey lines, established crustal deformation and fault offset monitoring at over 200 sites and deployed other geophysical and geochemical monitoring equipment at 150 locations in California. These data are collected at centers in Menlo Park and Pasadena, Calif.

Although the data from this monitoring effort are reviewed regularly, the effort does not constitute an operational prediction system in the sense that the data are interpreted on a 24-hour basis and available continuously and in real-time through robust communications links.

You have asked us to provide suggestions for improving the coordination and organization of Federal earthquake activities. As you are aware, FEMA has been given by Congress the role of planning and coordinating the Federal program. We offer the following suggestions.

We would benefit from a stable organization in FEMA so that long-term continuity between responsible individuals in both our organizations can be attained. FEMA needs greater stability of funding for support of earthquake hazard reduction activity by State and local governments.

This would enable the USGS to be more effective in the planning and implementation of its research. Greater clarity in planning and follow-through of plans by FEMA over periods of at least 5 years would lead to a better overall integrated program.

In addition to these suggestions, we have begun a review of the earthquake hazard mitigation activities within the Geological Survey. This review will involve both Government and nongovernment specialists and at least two meetings or workshops and will result in a 5-year plan of our activities. We intend to focus our efforts in those areas where applicable results are most likely to be obtained. The initial step of this review has been to solicit by letter the opinions of over 300 specialists and Government officials on the future emphasis of our program.

Finally, we have been asked to suggest new or improved Federal activities necessary to help State and local governments and the private sector with their earthquake mitigation activities. Because the application and implementation of research results are at least as difficult as the research itself and require a major sustained effort, we have focused on some new activities during the past year, as well as a continuation of the past activities that have proven successful.

These include a workshop on preparing for and responding to a damaging earthquake in the Eastern United States. This workshop was cosponsored by FEMA and is the first to bring together for interactive discussion and planning individuals representing public policymakers and representatives of the scientific and technical community.

The participants produced a draft 5-year action plan for improving the state of earthquake preparedness in the East. It provides a basis for public policy development and a guide for research. Similar workshops are planned for later this year.

A professional paper, "Facing Geologic and Hydrologic Hazards—Earth Science Considerations": This report answers some of the broader questions concerning earthquakes, floods, ground failure, and volcanic eruptions and quantifies their economic impact on the Nation. It also sugests actions which can be taken in every community to reduce losses.

This report has been disseminated in every State, adopted as a text at three universities, and is being used to inform city managers and local officials. We intend to encourage and expand activities such as these, synthesizing research results in forms useful to State and local officials and bringing those officials together in a workshop or other environment to explain our results and respond to questions on their application.

This concludes my oral statement. I thank you for your kind attention and would welcome any further questions from the members of the joint committees.

[The statement follows:]

STATEMENT OF DR. DALLAS L. PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

This statement describes the national program which the U.S. Geological Survey conducts under the Earthquake Hazards Reduction Act of 1977 and its reauthorizations in 1980 and 1981. It is submitted in response to the invitation of February 23, 1982, from the Honorable Harrison H. Schmitt and the Honorable Doug Walgren to the Director of the Geological survey to participate in a hearing on the reauthorization of the Earthquake Hazards Reduction Act of 1977. We request that this statement be included in the record of the hearing.

Purpose and scope.—The statement reviews specific responsibilities assigned to the Geological Survey under the Earthquake Hazards Reduction Act. It summarizes the goals, major accomplishments, and current emphases for each element of our program that is designed to carry out these responsibilities. It also describes briefly our management strategy for carrying out our work and for improving the dissemination and utilization of our results throughout the Nation.

Implementation responsibilities.—The Geological Survey is responsible for conducting five specific tasks set down in the implementation plan of the Earthquake Hazards Reduction Act. They are:

(1) To conduct research on the nature of earthquakes, earthquake prediction, earthquake hazards evaluation, and induced seismicity.

(2) To prepare national seismic risk maps.

(3) To evaluate earthquake hazards on a regional basis.

(4) To provide data and information on earthquake occurrences and hazards.

(5) To evaluate earthquake predictions with the advice of a National Earthquake Prediction Evaluation Council.

A sixth task—to acquire, analyze, and disseminate strong ground motion data—is currently performed by the Geological Survey for the National Science Foundation.

We have proposed that full responsibility and funding for this task be assigned to the Geological Survey in fiscal year 1983.

We strongly believe that each of these tasks is essential for preparing the Nation to reduce social and economic losses from future earthquakes. The Geological Survey, together with the Federal Emergency Management Agency, the National Science Foundation, and the National of Bureau Standards, is deeply involed and committed to the national effort to mitigate earthquake hazards. Our immediate goal is to develop and to conduct a comprehensive, coordinated, and focused program which will achieve scientific results giving all levels of Government, business and industry, the design and construction professions, and the research community, useful and timely information that can be used to improve earthquake preparedness, engineering and planning practices, and the development of public policy on seismic safety.

SUMMARY OF ACTIVITIES AND ACCOMPLISHMENTS

We will describe briefly some of the current accomplishments and activities in each of the five elements of our program:

(1) Earthquake Hazards and Risk Assessment,
(2) Earthquake Prediction Research,
(3) Earthquake Data and Information Services,
(4) Induced Seismicity, and
(5) Earthquake Hazards Warning and Information Dissemination.

Because we provided a comprehensive summary of our accomplishments and activities at the subcommittee hearing last year, we will focus mainly on those activities and accomplishments that are either new or that represent innovations.

Program review.—The Geological Survey has made a strong effort to improve productivity, to streamline methods of operation, and to enhance the utilization of its research in the Earthquake Hazards Reduction Program. In January 1982, because it had been 5 years since the passage of the Earthquake Hazards Reduction Act, a thorough review of the Survey's earthquake hazards reduction program was initiated. This review involved both internal and external participants who were requested to take a critical look at the program, asking:

(1) What have been the major accomplishments during the past 5 years?
(2) What scientific directions should be emphasized in the future to take advantage of this progress.
(3) What changes should be introduced in our program structure and objectives to achieve our national goals?

The review will be completed in June 1982. Its recommendations will influence our management decisions in fiscal year 1983 and beyond.

Earthquake hazards and risk assessment element.—The goals of this program element are to identify the potential for ground shaking, surface faulting, and earthquake-induced ground failures on a national and regional basis, to assess the risk from each hazard, and to devise predictive capabilities and mitigation strategies.

Accomplishments.—The most significant accomplishment of this program element is a new series of national maps depicting the ground-shaking hazard in the conterminous United States and Alaska. These maps which were completed in 1981 are formatted so that they can be used as seismic risk maps. The maps, at a scale of 1:7,500,000 (about 120 miles per inch) synthesize interdisciplinary research conducted since 1973. They show the levels of peak ground acceleration and peak ground velocity (two ground motion parameters used in earthquake-resistant design) that should not be exceeded at sites underlain by rock for a 90 percent probability level and for exposure times of 10, 50, and 250 years. The maximum levels of peak ground acceleration expected at sites underlain by rock (at the 90 percent probability level) throughout the Nation in a 50-year period of time reach 0.8g (g is the acceleration of gravity) in coastal California near the San Andreas fault and 0.3g in the Mississippi Valley. The values shown on the map have only a 10 percent probability of being exceeded at rock sites during the given exposure time. However, they may be larger at locations where the surface geologic materials are not rock but unconsolidated, weak, or water-saturated sediment that can amplify ground motion in selected frequency bands, causing the level of peak ground shaking to last longer and to be more intense.

When an exposure time of 250 years instead of 50 years is considered, the maximum value of peak acceleration in rock along the San Andreas fault (at the 90 percent probability level) only rises slightly, but the maximum value of peak ground acceleration in the Mississippi Valley increases substantially to 0.7g. Also, during an exposure time of 250 years, every part of the United States except for a small portion of southern Texas, Louisiana, Mississippi, Alabama, and Florida could experience levels of peak ground acceleration in excess of 0.04g, a level of shaking that could damage some structures that are not designed and constructed to be earthquake resistant. The building wealth exposed to the ground-shaking hazard is in the trillions of dollars.

These maps help to transfer research results from geology, geophysics, and seismology to the design and engineering professions and are appropriate for many future applications such as building codes.

The appearance of simplicity in the ground-shaking hazard maps conceals the large number of research results that made the maps possible. These results were attained by the Survey's program from the disciplines of geology, geophysics, and seismology. These results include:

(1) Location of new active faults and earthquake source zones in the Northeastern United States, the central Mississippi Valley, the Salt Lake City region, Washington State, and California by geologic field work and by seismic networks.

(2) Location and delineation of deep, earthquake-generating geologic structures through the use of seismic refraction and reflection techniques and gravity and magnetic surveys.

(3) Better estimates of magnitudes and the frequency of occurrence of historic earthquakes in California, Utah, and the Mississippi Valley through studies of historic seismicity, geochemical dating, and detailed geologic studies of active fault zones.

(4) Evidence that seismic energy, and thus strong ground shaking, decays less rapidly as distance from the fault increases in the Eastern United States compared to the Western United States. Although great earthquakes in the east are infrequent, their effects are many times more widespread than great earthquakes in the West. Accordingly, structures in the East are vulnerable to even moderate ground motion.

(5) New evidence gained from the magnitude 7.0, 1979 Imperial Valley, California, earthquake on the strength and spatial variation of strong ground motion within 6 miles of the causative fault. These unique data will influence the criteria presently being used for earthquake-resistant design.

Current emphases.—Research tasks now receiving priority emphasis in this program element include:

Establishing an accurate and reliable national earthquake data base with standard methods of locating earthquakes, assigning magnitudes, and estimating uncertainties associated with the parameters that are used to quantify an earthquake.

Publication and dissemination of the new probabilistic ground-shaking hazard maps for the Nation completed in 1981.

Delineation and evaluation of earthquake hazards and risk in urban regions of the United States that are earthquake-prone, including: Los Angeles, San Francisco, Seattle, Salt Lake City, St. Louis-Memphis, Charleston, and Boston.

Earthquake prediction research element.—The goal of this program element is reliable, short-term prediction of the magnitude, time, and location of major earthquakes. This research effort seeks to provide a physical basis for reliable earthquake prediction through the understanding of the mechanics of faulting and the "seismic cycle" of specific faults.

Accomplishments.—In the past year in California, the Earthquake Prediction Research Element supported the operation of 500 telemetered seismograph stations, 25 geodetic strain monitoring networks containing several hundred survey lines, monitoring of crustal deformation and fault offset at 288 sites, and monitoring of various other geophysical and geochemical precursors at 148 sites. These sensor networks are designed to take advantage of the "opportunity to learn" provided by the distinct increase in seismicity in California and the growing awareness of the increased probability of a major earthquake occurring in southern California. At the present time, the probability of a great earthquake along the southern San Andreas fault alone, some 30 miles from Los Angeles, is currently rated at 3-5 percent per year and about 50 percent in the next 30 years. The probability of smaller, but still damaging earthquakes, is even greater.

Seismic gap theory, earthquake recurrence models, seismicity patterns, and crustal strain data have been used to assess the intermediate-term hazard along the entire San Andreas fault system which generated the great 1857 Fort Tejon and 1906 San Francisco earthquakes, as well as numerous other smaller damaging events. Four distinct segments of the San Andreas fault have been evaluated:

(1) The northern 430 km-long segment which ruptured in 1906.—This segment appears to have an average return time of approximately 150 years for an event the size of the 1906 event. However, the "seismic cycle" data suggest that this region will experience magnitude 6-7 earthquakes at the rate of about one per decade. The

vicinity of San Juan Bautista appears to have a high potential for the occurrence of moderate to large earthquakes and has been designated as a special study area.

(2) The 160 km-long north-central segment.—This segment appears to have a very low potential for producing a major earthquake in the near future, although it is now characterized by the occurrence of numerous earthquakes having magnitudes of 5 or less.

(3) The 350 km-long south central segment.—This segment of the fault, which last ruptured in a magnitude 8.3 earthquake near Fort Tejon in 1857, has been determined to have a mean recurrence time of about 140±30 years for great earthquakes. The probability of a great earthquake occurring on this segment is currently rated as 3-5 percent per year.

(4) The 190 km-long southern segment.—This segment of the fault terminates in the Imperial Valley, one of the most active seismic areas in California which historically has produced magnitude 6 and larger earthquakes at a nearly constant rate. Although no major earthquakes are known to have occurred on this segment from either the historic or geologic records, all of the features believed to be symptomatic of a high potential for a major earthquake appear to be present.

Frequent surveys of geodetic networks represent one of the most promising approaches to the problem of detecting intermediate- or short-term anomalous crustal movements preceding damaging earthquakes. Data collected since 1973 from 5 of 7 trilateration networks in southern California indicate that a significant and widespread change in the pattern of strain accumulation may have occurred in 1978-1979. Although there was no apparent correlation between this regional strain episode and detailed seismicity patterns, the change does coincide in time with a widespread increase in magnitude 5 and greater earthquakes. Since 1978, earthquake swarms and earthquakes having magnitudes of 5 or greater have occurred in southern California at a rate that is three to five times greater than the rate experienced in the 25-year period 1955-1978, but it is comparable to the pre-1952 period. In addition, a numbe of possible anomalies, including changes in water levels and radon gas emanations, have been observed.

In July 1980, the Director of the USGS informed the California Department of Emergency Services that the southern California area should be considered in a state of Hazard Watch. This watch was reemphasized in 1981.

Current emphases.—The Earthquake Prediction Research Element continues to support fundamental research and data-gathering activities, focusing on areas having high seismic risk such as: California, Puget Sound, Alaska, the Mississippi Valley, and the Northeastern United States. The goal is to develop a reliable methodology for forecasting the time, place, and size of damaging earthquakes. Cooperative research efforts to accelerate learning are continuing to be conducted with host countries at locations outside the United States where large earthquakes take place much more frequently than in the United States.

Two strategies are being used:

(1) To develop a sound theoretical basis needed for making long-term forecasts through a deeper understanding of the "seismic cycle" of a fault system and the physics of the immediate pre-earthquake failure process. Theoretical, laboratory, and field studies are used to carry out this strategy.

(2) To develop an adequate empirical data base for devising criteria for making short- and intermediate-term forecasts stated in probabilistic terms. In the original design of the Earthquake Prediction Research Element beginning in Fiscal Year 1978, it was estimated that attainment of enough experience to demonstrate the capability for reliable earthquake forecasting would require detailed observations on multiple-sensor networks of at least 10 earthquakes of magnitude 5 or larger. The rate of acquiring these observations depends on the frequency of earthquake occurrence and the area covered by the observational networks. It was estimated initially that 8 to 10 years would be required to obtain these observations. Since the beginning of FY 1978, three earthquakes of this size have occurred within or adjacent to detailed networks—the last being the magnitude 7.0 Imperial Valley earthquake of October 1979.

The lack of an adequate data base of observations for large (magnitudes of 7-8) and great (magnitudes of 8 and greater) earthquakes is currently the most serious impediment to the development of the capability for making reliable earthquake forecasts in the United States. We are actively working to overcome the fact that the historical record of large and great earthquakes in the United States is relatively short compared to many other regions of the world.

Earthquake data and information services element.—The goal of this program element is to collect, analyze, and disseminate information on the occurrence and effects of earthquakes to the public, to the research community, and to public officials at all levels of Government who are involved in earthquake mitigation efforts and the development of public policy on seismic safety.

Accomplishments.—The Geological Survey has continued to support the development of a comprehensive and accessible global seismograph network and data base. Because several million earthquakes happen throughout the world each year, the operation of global networks has accelerated our understanding of earthquakes and global tectonics, and a data base that is unprecedented in quality and scope is now beginning to be developed. Digital data recording has proved to be one of the most important innovations in seismology; it not only provides much greater resolution and recording range, but also greater efficiency in computer processing and analysis. Digital data are currently being recorded on the Global Digital Seismograph Network, analyzed, and made available to research organizations throught the world. Applications of these data include: studies of the internal structure of the Earth, routine publication of expanded lists of earthquake parameters, and detailed research on the faulting process of large earthquakes.

Maps of historic seismicity are being compiled for each State in the United States. The effort began with the Eastern States and, at the present time, 34 maps have been completed and published. These maps are being used in many practical applications, including: environmental reviews, earthquakes resistant design, and earthquake preparedness planning.

Data on about 15,000 of the largest earthquakes occurring worldwide and causing more than 13,500 deaths during 1980 and 1981 were provided following each event to a wide variety of users by the National Earthquake Information Service (NEIS). The NEIS provides immediate notification almost every day of earthquake location and magnitude to State and Federal emergency agencies, the Office of Foreign Disaster Assistance, news services, and other users. Early notification of the location and magnitude of earthquakes strong enough to be felt in the United States is important because: the public is quickly advised of the cause of ground shaking (not an explosion or catastrophic accident), local officials can inspect critical structures in the epicentral area for damage (such as dams and bridges), and disaster relief, if warranted, can be directed to the appropriate location.

Current emphases.—The current emphases include:

Continuation of the activities of NEIS to provide announcements and information on earthquakes in the United States and throughout the world and to disseminate the data.

Supporting the operation of seismograph networks in the United States and worldwide to provide original data on earthquakes for research on the structure of the Earth and the earthquake process.

Continuation of the publication of historic seismicity maps for each State.

Induced seismicity element.—The goal of this program element is to determine how water impoundment and other activities of man cause earthquakes and to devise and recommend steps that can be taken to mitigate the hazard.

Accomplishments.—In an effort to gain a complete understanding of the physics associated with earthquakes induced in some cases by activities of man such as water impoundment, subsurface fluid injection, and underground excavation, a comprehensive and unique set of geophysical measurements were made at Monticello Reservoir. The reservoir, located about 45 km northwest of Columbia, South Carolina, was built in 1977 to provide cooling water for the V. C. Sumner Nuclear Station. Although the reservoir is only 25 m deep, more than 3000 earthquakes have occurred following the impoundment. All of the earthquakes have been small, but two of them (magnitudes 2.7 and 3.0) caused ground motion having a peak acceleration, respectively, of 0.25 and 0.35g. The experiments conducted in the boreholes included direct measurements of: (1) the stresses, or forces, in the rock causing the earthquakes, (2) the amount of pressure in the water filling the cracks and pores in the rock, (3) the nature of subsurface fault zones in the rock, and (4) the permeability of the rock which is a measure of the ease with which water can move through the rock. Analysis of these data showed that the reservoir-induced earthquakes were the result of the movement of pre-existing faults in the rock. The increase in the water pressure at depth, which resulted from impoundment, triggered these faults causing the release of the high stresses already existing in the rock at a very shallow depth. The research suggests that careful management of the water level in the reservoir can help to reduce the frequency of occurrence of furture earthquakes. This strategy, coupled with appropriate earthquake-resistant design, to withstand the high g-levels of ground shaking generated in some cases by the small earthquakes, can keep induced earthquakes from adversely affecting the structures at the site.

Current emphases.—The current emphases include:

Continuation of intensive field investigations at Oroville Reservoir in California, the site of a magnitude 5.7 earthquake in 1975. The investigations will seek to determine if that earthquake was reservoir induced, to estimate the risk at the site, and to assess the potential hazard to other dams and reservoirs planned along the western foothills of the Sierra Nevada Mountains.

Earthquake hazards warning and information dissemination element.—The goals of this program element are: (1) to transmit information and technical data as well as warnings about earthquake hazards to public officials at all levels of Government throughout the Nation, to scientists and engineers, to professional organizations and societies, model code groups, and others, (2) to establish "good neighbor" partnerships between the Geological Survey and Federal, State, local, and private elements of the Nation, and (3) to identify local experts in every region of the Nation and to stimulate them to accelerate their learning about hazards and to adopt a policy for the implementation of measures that will reduce losses from earthquakes.

Accomplishments.—The major accomplishments of this program element are described below. These accomplishments are noteworthy because the application, or implementation, of research results is at least as difficult as the research and requires a major sustained effort involving any activities.

In September 1981, the Geological Survey and the Federal Emergency Management Agency sponsored a workshop on "Preparing for the responding to a damaging earthquake in the Eastern United States." This workshop brought together, for the first time, 70 individuals representing local, State, and Federal Government, business and industry, and the research community. Collectively, they had backgrounds and interests in disaster preparedness, disaster response and recovery, earth sciences, engineering, social science, law, economics, insurance, architecture, and land-use planning. The participants produced a draft 5-year action plan containing recommendations for improving the state-of-earthquake-preparedness in the Eastern United States. Although the recommended plan has not yet been adopted as public policy, the plan can serve as a guide for public officials, the design professions, and the research community to use in developing plans, programs, and projects to reduce losses from earthquakes and to develop a seismic safety policy in their respective communities. Three noteworthy earthquakes have occurred in the east since the workshop—in the New Brunswick area just east of the Maine border, in New Hampshire, and in Arkansas.

In November 1981, the Geological Survey published a professional paper, "Facing Geologic and Hydrologic Hazards—Earth Science Considerations." This report was designed to answer some of the broader questions concerning earthquakes, floods, ground failures, and volcanic eruptions and to quantify their impact on the Nation. The report also suggested actions, based on earth-science considerations, which can be taken in every community throughout the Nation to reduce losses.

In February 1982, the Geological Survey joined with the business community of southern California to improve earthquake preparedness and planning. One of the immediate efforts is a conference on May 4-5, 1982, in Los Angeles. It is expected to attract some 750 participants for business and industry. This effort marks the beginning of a significant contribution by business and industry to earthquake hazard reduction.

Research findings of the Survey's earthquake hazards reduction program are being utilized by the State of California in new maps of the Los Angeles and San Francisco urban regions to help define strategies for reacting to a catastrophic earthquake. These maps, which show the intensity of ground shaking on a scale ranging from 1 (least severe) through 10 (most severe), were compiled by the California Division of Mines and Geology for the Governor's Earthquake Task Force. Advance copies for the Los Angeles and San Francisco regions displayed at a legislative press conference in Sacramento on February 9 received comments from legislators and emergency management specialists in State government. The maps use predictive methods and earth science data produced in USGS research; USGS scientists also worked with their counterparts in the State agency to facilitate the compilation. The maps show how the intensity of ground shaking changes with distance away from the earthquake fault, with local geologic materials, and with depth to groundwater. The implication is that some of the most severe ground shaking will be miles from the fault, but as sites underlain by soft, uncompacted water-saturated mud.

No new geologic Hazard Watches were issued in 1981. However, the two Hazard Watches issued in 1980 for Mammoth Lakes and southern California were reassessed. In both cases, the Director of the Geological Survey notified the Director, Office of Emergency Services of the State of California, that the Survey saw no reason to alter the watch notification. Both Hazard Watches are still in effect. Since the Hazard Watch was established in the Mammoth Lakes area, two moderate earthquakes, a magnitude 6.0 on May 27, 1980, and a magnitude 5.9 on September 30, 1981, have occurred.

Current emphasis.—The current emphasis of this program element include:

Continuing to provide liaison and advisory services to groups such as the Association of Bay Area Governments and the Southern California Earthquake Preparedness Project.

Participating in the Interagency Committee on Seismic Safety in Construction, which is working on a variety of tasks including a manual of standard practice for evaluating earthquake hazards at Federal construction sites.

Working through Earthquake Engineering Research Institute, a professional organization, to develop regional seminars in Boston, Massachusetts; Raleigh, North Carolina; Memphis, Tennessee; Salt Lake City, Utah; Seattle, Washington; and Anchorage, Alaska, on topics in geology, seismology, and earthquake engineering. These seminars are expected to begin in 1982 and to provide an opportunity for practicing design professionals, building officials, and policymakers to learn about the latest technical and scientific results that can be applied in earthquake-resistant design to reduce losses from earthquakes.

Sponsoring workshops and conferences to disseminate information and to stimulate actions leading to earthquake hazards reduction.

Dissemination of research results through scientific and technical journals and Government publications. In 1980 and 1981, our staff published 400 papers and reports on their research related to earthquake hazards.

MANAGEMENT STRATEGIES

Below we discuss certain aspects of the management of our efforts under the national program.

Within the Geological Survey, the responsibility for carrying out the Earthquake Hazards Reduction Program is assigned to the Office of Earthquake Studies. This office manages the program and conducts research and investigations using its staff of approximately 250 full-time scientists, engineers, and support personnel. This Office also supports closely coordinated contract research and work with universities and industry using about one-quarter of our total program resources. This strategy has succeeded in (1) greatly augmenting our capability without increasing our personnel, (2) identifying and improving local expertise in almost every region of the Nation, and (3) giving qualified scientists throughout the Nation an opportunity to participate in the program.

Planning for our role in the program began in 1977. At that time, the Geological Survey anticipated the need for a plan to guide non-Survey participants and took steps to create a draft research plan. Its purpose was (1) to define short- and long-term research objectives, (2) to identify strategies for achieving optimum research results, (3) to provide a mechanism for obtaining continuous feedback and for integrating results of ongoing research into the plan, and (4) to give Survey management and others a tool for evaluating and deciding on the options for future research and a basis for allocating resources. The initial research plan has evolved into the "5-year plan" that is currently used by the Office of Earthquake Studies to manage its internal and external research. It contains clear objectives and milestones. It is a dynamic working document that is reviewed every year, updated, and refined in terms of new knowledge, actual accomplishments, national needs, and available resources.

In closing, we believe that our program is well defined, well balanced, well managed, and on the road to reducing earthquake hazards in the United States. Considerable progress has been made, but much remains to be done to accomplish our goal of reducing losses throughout the Nation from earthquakes. We are prepared to answer any questions you may have.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. The Committees understand that NASA, through its Geodynamics program, is experimenting with interferometric techniques for study crustal dynamics. What seems to be the potential for space-based monitoring for predicting earthquakes? Is the USGS exploring any possibilities for monitoring seismic activity from space?

Answer. The U.S. Geological Survey (USGS) has signed an interagency agreement with NASA to coordinate and cooperate in crustal dynamic studies using space-related techniques. Space-related techniques are being developed that may be applicable to measuring small strains in the Earth's crust and, thus, may be useful for earthquake prediction. To date, these techniques have not reached the level of reliability or accuracy that can be achieved with conventional surveying techniques. We continue to follow closely the development of space-related strain monitoring techniques. Along with several other agencies (NOAA, DMA, and NASA) we are providing funds ($50K/year) for the development of a geodetic receiver to be used with the Global Positioning Satellite System. In our opinion this technology is most likely to be useful in crustal strain monitoring.

Question. The program on strong motion data gathering hs been transferred from NSF to USGS. At the same time, the Earthquake Hazards Reduction Program in USGS has been reduced by $2.6 million "in order to support higher priority programs." What is to prevent the strong motions program from disappearing in the future, "to support higher priority programs?"

Answer. The USGS feels a strong commitment to maintain the Earthquake Strong Motion Program at a level that will meet the needs of engineers and architects involved in seismic-resistant design and construction practice research. We have no intention of sacrificing the strong motion work to support other elements of the earthquake program in the future. If we did, our credibility would be destroyed both with NSF and the seismic engineering community.

Question. How do U.S. investments in earthquake prediction compare with those of foreign countries such as the USSR, Japan, and China?

Answer. The United States currently invests approximately $15 million per year in earthquake prediction, this includes all costs: salaries, equipment, supplies, operations and research. The U.S. program began in 1976.

Japan invested approximately $30 million in earthquake prediction in 1981. This figure does not include salaries and research. The Japanese program began in 1965.

The Soviet Union is currently investing 50 million rubles per year (about $75M) in earthquake prediction work. It is unclear what is included in this figure. The Soviet program began in 1949 or 1954 depending on the source of the information.

We can place no monetary value on the earthquake prediction program in the Peoples Republic of China (PRC). Approximately 10,000 scientists and technicians are involved and many additional volunteer observers. An independent agency, the State Siesmological Bureau, has been established to deal with earthquake problems in China. The PRC earthquake prediction program began in 1966.

Question. A major objective of the Federal earthquake activities is to develop an operational prediction capability. What amount of precision and reliability would be required for an operationally useful short-term prediction capability? How soon could a prototype prediction capability, perhaps covering only a region of the U.S., be established? Are any new research activities, in addition to those currently underway at USGS and NSF, needed to help us achieve an operational prediction capability by, say, fiscal year 1988?

Answer. The problem of short-term earthquake prediction is currently one of intensive research within the Geological Survey. To date, no reliable procedure or technique that will lead to unequivocal earthquake prediction on a short-term basis has been developed. To support prediction research dense networks of geophysical instrumentation have been deployed in several seismically active areas; but, our major effort has been in central and southern California. In these regions over 500 seismographic stations have been established and they transmit data in real time to automatic processing facilities at Pasadena and Menlo Park. Some 25 geodetic strain monitoring networks containing several hundred survey lines are remeasured on 6-month intervals. Crustal strain and fault offset are measured at 288 sites; other geochemical and geophysical observations are taken at an additional 148 sites. Some of these data are transmitted in real time to analysis centers, others are gathered by visits to the field installation. All of these data are reviewed periodically for evidence that might lead to an earthquake prediction and all are used in specific research directed towards evaluating the data in terms of earthquake prediction.

Our instrumentation effort is evolving toward a prototype prediction network in California. Instrumentation that yields reliable data is being improved, other observational efforts that proved unproductive are being cut-back. New efforts include the use of two-color laser geodimeters, used to measure crustal strain, that obviate the need for expensive measurements of the atmosphere along the line of sight.

Despite these observational efforts we cannot set a date on when operational prediction will be achieved. We need more experience with data recorded prior to earthquakes before we can fully evaluate our current networks. Unfortunately, with the Earth as our laboratory, we must wait for earthquakes to occur and cannot plan our experiments.

Question. USGS (bottom of page 6) states that USGS located new active faults and earthquake source zones in 1981. As a result of these findings, should more attention be devoted to mitigation at these areas? How are such data shared with FEMA for its priority setting?

Answer. The location of active faults and earthquake source zones has helped us to identify the cause of seismic activity in various regions and refine our estimates of the seismic risk. Our most significant result has been the identification of the geologic structure associated with the seismicity in the central Mississippi Valley. We held a meeting, with FEMA cooperation, in September 1981 to advise public officials at the State and local level of the nature of the seismic hazard in this region and what steps should be taken to mitigate this hazard. A follow-up meeting is scheduled for May 1982.

Results in studies of other areas are promulgated to FEMA in our series of semiannual reports and through direct contract.

Question. What makes the Earthquake Hazards Reduction Program a "low priority item," to justify a $2.6 million cut?

Answer. It is the policy of the Department of Interior to promote those programs that will protect the United States from future shortages in energy and strategic minerals. Given this policy and the President's economic goals, a reduction in the earthquake program is considered justified.

Question. Are the effects of a great earthquake in the Eastern States any different from the effects of a quake of the same magnitude in the Western U.S.? Why and how does this alter your research efforts for the Eastern States?

Answer. The Earth's crust east of the Rocky Mountains is much more different at propagating seismic waves than that west of the Rocky Mountains. The result of this is that a magnitude 5 earthquake near St. Louis is felt over a much wider region than a magnitude 5 earthquake near San Francisco. The former is potentially more damaging, however the latter is more frequent. These facts have been known for some time.

Earthquake-producing faults in the west can usually be identified from conventional geologic mapping. The San Andreas fault shows up on satellite photographs. Active faults in the east are often buried under several kilometers of recent sediment, such as along the Atlantic Coast or Mississippi Valley. These faults cannot be identified by conventional mapping thus expensive, sub-surface exploration techniques must be used to locate these features and map their extent.

Question. Is there a need to develop studies on options for improving instrumentation of the faults in southern California? Could you estimate the cost of a prototype study?

Answer. Yes, there is a need to develop design options and cost estimates for an operational earthquake prediction system. Then, if a breakthrough occurs in short-term earthquake prediction, we could proceed with the deployment of such a system without delay. We estimate such design studies would cost on the order of $300,000. If these studies recommend new instrumentation concepts, it would be desirable to test these concepts with prototype field installations. This would add $1.0M–$2.0M to the cost of the effort.

Question. Should consideration be given to a multi-year authorization for the Earthquake Hazards Reduction Act?

Answer. Yes, we would prefer a 2- or 3-year authorization to add stability to the planning and execution of our participation in the Earthquake Hazards Reduction Program.

Question. The USGS has released an excellent resource guide "Facing Geologic and Hydrologic Hazards, Earth-Science Considerations," as a resource tool for State and local governments. Can you cite additional outreach and dissemination activities that you have undertaken?

Answer. As cited in our testimony of March 11, 1981, the Geological Survey earthquake program includes an "Earthquake Hazards Warning and Information Dissemination element." A Deputy for Research Applications is assigned to the staff of the Office of Earthquake Studies. Through these mechanisms numerous workshops are held and publications prepared to provide the results of our research activities in an applicable form to the user community.

In September 1981, the Geological Survey and the Federal Emergency Management Agency sponsored a workshop on "Preparing for the responding to a damaging earthquake in the Eastern United States." This workshop brought together, for the first time, 70 individuals representing local, State, and Federal Government, business and industry, and the research community. A follow-up meeting is planned for May 1982.

Question. What is an Earthquake Hazard Watch? Has a "Hazard Watch" been issued by USGS recently?

Answer. The terms of warnings of geologic hazards were defined by the Director of the Geological Survey in the Federal Register of April 12, 1977. These definitions are:

"Notice of potential hazard. The communication of information on the location and possible magnitude or geologic effect of a potentially hazardous geologic event, process, or condition.

Hazard Watch. The communication of information, as it develops from a monitoring program or from observed precursor phenomena, that a potentially catastrophic event of generally predictable magnitude may be imminent in a general area and within an indefinite time period (possibly months or years).

Hazard Warning. The communication of information (prediction) as to the time (possibly within days or hours), location, and magnitude of a potentially disasterous geologic event or process."

The Geological Survey issued earthquake hazard watches for the Mammoth Lakes area of California on May 27, 1980, and for southern California on July 3, 1980. These watches were reaffirmed on October 7, 1981 and October 9, 1981, respectively.

Mr. WALGREN. Thank you very much, Dr. Peck. We appreciate that very much.

I would like to express my appreciation to Senator Schmitt directly for inviting us to participate in this joint hearing and say, as I said at the outset, that I think it is an extremely effective way for the Congress to try to hear what is going on in a program like this and develop our thoughts about it. So thank you very much.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. Well, Congressman Walgren, it is indeed my pleasure. Your full committee, as well as subcommittees, have returned the favor on other occasions on the House side. It seems this year to be working out very well and it is going to help us move legislative changes where they are necessary and certainly help us focus more comprehensively on the kind of oversight that our respective committees should be conducting.

I welcome all of the gentlemen from the other body, as I said, to this side of the Congress this morning and I apologize for my own uncertainty and difficulty in being here because of the very unfortunate activities that we are about on the Senate floor this week.

The issue of earthquakes hazards and the reduction of same is one of the most critical issues facing many of the people of this country. It is one which ever since I entered the U.S. Senate I have been trying to get some administration to take as seriously as I think those of us around the table take it. Earthquakes constitute a national problem since at least 39 States are known to face major or moderate seismic risk endangering literally tens of millions of persons.

Problems of earthquakes which 50 or 100 years ago were relatively nonexistent now endanger tremendous groups of people because of population growth and shifts in population. One of the most graphic recent examples of the change in our demographics, if you will, relative to natural hazards has been the publicity and activities surrounding the Mount St. Helens affair. In the last century Mount St. Helens was known to have errupted as violently or more violently than it did a few years ago, but nobody really knew much about it. It was in the legends of the Indians or in the reports of trappers in the region and that was about it.

But because of the vast increase in population in that area, suddenly what was not a hazard then becomes a very significant hazard now.

What we have seen in our research in Federal Government activities is that most of the resources in emergency planning in FEMA are dedicated to the anticipation and preparation for nuclear attack, and I do not begrudge that at all. I think having a strong civil defense force is an important part of the total deterrent picture that we must present to the world.

But the real danger of literally tens of thousands, if not millions, of people being killed or injured and billions of dollars in property damage comes from natural events, not from nuclear attack on a day-to-day basis.

In 1981 the U.S. Geological Survey issued a report which stated: "If an earthquake should occur today on the Newport-Inglewood fault near Los Angeles, it would probably cause losses of about $45 billion to buildings and as many as 23,000 deaths." I suspect the casualty toll would be several times that number. "A repeat of the 1811 and 1812 New Madrid, Mo. earthquake has been estimated to cause—roughly—comparable losses."

Well, that is, I think, not an unrealistic set of estimates and we have had our warnings. The San Fernando Valley earthquake was clearly a warning that not only caused injuries and some deaths but it illustrated the problem, the problem being that under current design standards, somewhat modified since then but I suspect not significantly, an earthquake of just that size basically destroyed the ability of emergency operations to be conducted.

Several hospitals were destroyed. Police communications and fire communications were destroyed. Gaslines and telephone lines were disrupted, freeways collapsed, and there was instant disruption of everything necessary to respond to a major catastrophe in that area. Fortunately, the earthquake was a mild one by geologic standards and even by southern California standards.

The U.S. Congress moved to combat the hazards of earthquakes by enacting the Earthquake Hazards Reduction Act of 1977. The following year, the administration, in compliance with the act, established an earthquake hazards reduction program.

The act and the program recognize that earthquake hazards reduction is a joint responsibility shared by State and local governments, various elements of the private sector, and the local government. It also recognizes, I believe, that good planning for earthquake hazards reduction does contribute directly to our ability to handle other civil defense crises.

Federal activity related to earthquakes has increased greatly since the act was passed in 1977, at least in the research area. Funding has increased from $24.3 million in fiscal year 1977 to an estimated $59.6 million for fiscal year 1982. A great deal of research-derived knowledge has been generated. However, there is some question of whether that knowledge has been realistically applied to actual hazards reduction.

There do seem to be major problems. Discussion with many people inside and out of the Federal Government suggests the following: The Federal Government has shown little leadership and assigned a low priority to stimulating State and local governments and various elements of the private sector to undertake comprehensive earthquake mitigation efforts.

Second, although there is some activity within many States, only California seems to be making substantial progress. And there I think most would say it is still greatly inadequate. A great deal needs to be done to develop mitigation capabilities in such relatively high risk areas as the central United States, Utah, Puget Sound, Charleston, S.C., Boston, and Puerto Rico.

Third, the United States is still far from having an operational earthquake prediction capability comparable to that that exists in some other nations of the world.

And, finally, the Federal Government has downplayed its assistance to State and local governments and has made, at best, modest efforts to apply the findings of research which has been conducted.

Last Friday, FEMA submitted the "Fiscal Year 1981 Report to Congress on the National Earthquake Hazards Reduction Program." The report's concluding paragraph stated in part: "Managerial problems also exist and are being addressed. The NEHRP needs a well-articulated, coherent program plan, the preparation of which should be a priority item. Also, coordination among the Federal agencies should be improved"—that quote after several years of being assigned the responsibility.

I am glad the FEMA and other agencies are at least acknowledging problems that many of us have been raising for years. Members of both the Senate and House are very concerned about these problems in our earthquake program. I believe that this joint hearing indicates the resolve of the House and the Senate to work together with the administration to address these problems and to develop an effective national earthquake hazards mitigation capability.

I once again want to thank my colleagues from the House for being with us and to thank the witnesses for being here. Congressman, I will turn it over to you because heaven only knows when we will get three lights up there.

Mr. WALGREN. Thank you very much, Senator Schmitt.

Let us continue, then, with the statements from the panel. The next two witnesses both come from the National Science Foundation. In the interest of time, gentlemen, although we are not being strict or anything like that, I am hoping that since there are two witnesses from the National Science Foundation you might be able to get in a little under 10 minutes each and then we will be able to move this hearing well.

But let me first recognize Dr. Sanderson, the Assistant Director for Engineering. Dr. Sanderson.

STATEMENT OF DR. JACK SANDERSON, ASSISTANT DIRECTOR FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION

Dr. SANDERSON. Thank you, Mr. Walgren.

Since you are including my formal statement in the record, I will summarize it briefly. The statement reports on both significant progress achieved and significant opportunities to move further in research on earthquake hazard mitigation.

In the Foundation, responsibility for the earthquake hazard reduction program is divided between myself in engineering, and Dr. Johnson in the fundamental earth sciences relating to prediction.

Since the Earthquake Hazard Reduction Act was passed in 1977, the Foundation has substantially increased its activities in this area. We have obligated in the past several years about $110 million, 80 percent of which has been in engineering. The program itself within NSF dates back to the late 1960's and the early 1970's.

In engineering, funding for the program was increased significantly in 1977, as Senator Schmitt pointed out, from a level of about $9.3 million the preceding year to something over $17 million in fiscal year 1978. It has remained essentially constant since that time.

In engineering, research is divided into three general categories: Siting research, attempting to understand what happens in the ground during a period of major strong ground motion and how foundations of buildings and other structures interact with strong forces in the ground; design research, attempting to understand the dynamic behavior of manmade structures, such as buildings and the so-called lifeline facilities—gasolines, water and sewer pipes, dams, powerplants and communications channels; and social response, attempting to understand ways of providing better preparation and postdisaster services in emergency areas.

We have, as is consistent with the Foundation charter, emphasized research activities and dissemination of the results of that research to the appropriate communities.

Because of the high priority we attach to disseminating earthquake research results and their importance to the Nation, we have gone beyond the normal Foundation mode of disseminating results to fund and encourage a number of informational activities. These include a national information service for earthquake engineering at the University of California-Berkeley and at the California Institute of Technology, as well as a more social science-oriented dissemination activity at the University of Colorado. We have also recently been working with the Academy for Contemporary Problems to develop a resource referral service directly aimed at helping State and local officials. In addition, we each year sponsor a number of seminars in seismic risk areas throughout the country to disseminate information to practicing engineers, other researchers, and State and local officials. These seminars deal with the current state of knowledge in seismic-related research.

We have formally some 10 groups which I listed in my testimony as points of direct coordination activities involving the National Science Foundation. We also have regular contact with FEMA, USGS, the Bureau of Standards, and the other participants in the Federal program.

During the past several years, we have been able to benefit a great deal from the global interest in seismic disaster prevention by cooperative research agreements. The largest of these research agreements has been with Japan, where unique, large-scale testing facilities have produced a major step forward in the understanding of seismic response of buildings. We also have cooperative programs with other countries, such as the People's Republic of China, Taiwan, Indonesia, Italy, and Mexico.

Whenever a major disaster occurs, we have through contracts with the National Academy of Sciences and the Earthquake Engineering Research Institute postdisaster teams who will go immediately to the site to collect data. During this past year, these postdisaster teams have followed seismic events in Algeria, Italy, and Greece. We use not only the laboratory but also natural phenomena as bases of data for better understanding of earthquake research.

During the coming year, we will be looking at the possibility of modifying existing facilities in this country, such as the NASA facility at Huntsville, for use in the earthquake engineering research program.

In 1969, Dr. Housner chaired a committee of the National Academy of Sciences to look at the state of earthquake hazard knowledge and to recommend for a research agenda. Dr. Housner is now chairing a second such committee and we anticipate that there will be a major report from that committee during this calendar year. That certainly will be a significant component of our planning activity.

For the future, we are looking at large and full-scale testing activities and at the possibility of increasing the instrument arrays in the highly seismic areas of the world. We are concerned with the behavior of low-rise structures, which are the dominant component of our building stock, and particularly the problem of retrofitting structures constructed before seismic codes were in place.

In my view, there are real opportunities for further research, but real progress has been made. I will be pleased to respond to any questions you might have.

[The statement follows:]

STATEMENT OF DR. JACK T. SANDERSON, ASSISTANT DIRECTOR, ENGINEERING, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and Members of the Subcommittees. I am pleased to report to you today on the progress made in earthquake research as a result of the programs in the Engineering Directorate (ENG) and the Directorate for Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO). Since the passage of the Earthquake Hazards Reduction Act in 1977, NSF has obligated approximately $110 million on seismic research in the two directorates. About 80 percent of the funds have been obligated by the Engineering Directorate and 20 percent in AAEO.

These programs have been an effective expenditure of public funds. I will first discuss the Earthquake Hazard Mitigation Program (EHM) which now resides in the Divison of Civil and Environmental Engineering (ENG) and Dr. Francis S. Johnson will then describe the related activities within the Division of Earth Sciences (AAEO).

The national importance of the earthquake problem is clearly indicated by the fact that only five (5) states (North Dakota, Minnesota, Wisconsin, Louisiana, Florida) are believed entirely free of seismic risk. When one considers that many recent damaging earthquakes have originated on "inactive" faults, almost no state can completely dismiss the potential hazard. Although the greatest seismic hazard is presently believed to be on the West Coast, within the past few weeks earthquakes have been recorded in New England and in the Southern U.S., both areas classified as being at low seismic risk. Each year that passes brings us closer to the dreaded large earthquake in a major metropolitan area, which could cause undue property damage and loss of life unless we are prepared.

The EHM Program has remained intact at NSF since the early 1970's. As reorganizations have occurred over the years, the EHM Program has functioned consecutively within the Directorate of Research Applications (RA), the Directorate for Applied Science and Research Applications (ASRA), the Directorate for Engineering and Applied Science (EAS), and now resides in the Directorate for Engineering

(ENG). Funding for this Program was increased from $9.3 million in fiscal year 1977 to $17.7 million in fiscal year 1978 (following passage of the original Act), and has remained essentially constant since that time. The importance of the earthquake problem in society will cause us to re-evaluate the levels of funding for future years.

The general objectives of the EHM Program are to minimize property damage and loss of life from potentially damaging earthquakes. To accomplish the objectives requires broad participation in the program by architects, urban planners, earth scientists, geotechnical engineers, structural engineers, and social scientists. The EHM Program is divided into three general areas whose specific objectives are:

SITING RESEARCH

To determine the nature of strong ground shaking from instrument data taken during earthquakes; to develop analytical models that will predict the spatial and temporal distribution of strong ground motion at different sites; to understand the dynamic behavior of soil and rock subjected to strong shaking; and to determine the nature of the interaction of structures and the supporting soil during earthquakes.

DESIGN RESEARCH

To develop procedures for dynamic analyses of proposed or existing construction under earthquake loadings; to develop an understanding of materials and structural components subjected to damaging dynamic loads; to develop procedures for analysis and design of non-structural and architectural systems; and to study the influence of architecture and urban planning activities on earthquake vulnerability.

SOCIETAL RESPONSE RESEARCH

To develop and evaluate measures which can be used to mitigate and respond to earthquake impacts, including emergency preparedness, land-use planning, building codes, insurance, and information and education.

Because of the urgency in making preparations for a major earthquake, we have not been content with only reporting research results in technical journals, but have attempted to accelerate the utilization of findings. This has required extensive interaction with other Federal agencies, and when appropriate, with state and local officials. The researchers also have the added responsibility tc interact with the ultimate users of the research. This has not been unusually difficult because the EHM Program has attracted many of the most productive and respected researchers and engineers in both the universities and the private sector. Many of the participants in the Program are members of the National Academies of Science or Engineering, and are eminent researchers and consultants. The stature and wide ranging involvement of such individuals have provided a direct mechanism for introducing research results into practice. In a more traditional mode, the EHM Program has established the National Information Service for Earthquake Engineering at the University of California, Berkeley and at the California Institute of Technology. The facilities attempt to retain all pertinent information on earthquake engineering (including data from foreign countries) in the form of publications, computer codes and journal abstracts. Similar cataloging of pertinent information on the social science aspects is maintained in the National Hazards Research and Applications Information Center at the University of Colorado. The Academy for Contemporary Problems has recently established the Resource Referral Services for state and local public officials. Coordination with other agencies is accomplished both on a formal and informal basis. Direct participation in the following organizations has provided NSF an effective mechanism for coordination:

Interagency Coordination Committee on the National Earthquake Hazard Reduction Program.
Universities Council on Earthquake Engineering Research (UCEER).
Earthquake Engineering Research Institute (EERI).
U.S.-Japan Committee on Natural Resources (UJNR).
Committee on Seismology (NAS).
International Tunneling Association (ITA).
Interagency Discussion Group on Disaster Mitigation.
Interagency Committee on Seismic Safety in Construction.
Building Seismic Safety Council (BSSC).
Advisory Committees (NSF, USGS).

FEMA, the lead agency for Federal seismic programs, recently established the Interagency Coordination Committee on the National Earthquake Hazards Reduction Program, which will provide a formal coordination for the involved agencies on a periodic basis. Extensive interaction and joint research projects with the U.S. Geological Survey (USGS) are also an integral part of our Program. One important activity has been the funding by NSF of the national strong motion instrumentation program, which is conducted by the USGS. To effect better coordination, we will be transferring the funding of the strong motion program to the USGS in fiscal year 1983.

While each research project is making a contribution to our understanding and mitigation of earthquakes effects, I would like to highlight a few of the more significant recent achievements to give you an idea of the wide range of activities in which we are engaged.

Theoretical advancements and computer technology have resulted in models that have been able to reproduce actual recorded seismograms recorded for past earthquakes. When the input parameters for a specific site have been determined, these ground motion models will be capable of predicting the damaging ground motions for a future earthquake. This was considered an impossibility just a few years ago.

To verify experimentally new concepts and develop an understanding of materials and structural behavior under seismic loading conditions, it is necessary to simulate actual earthquake ground motions. This has been accomplished in the laboratory by the development of one- and two-dimensional "shake tables", and cyclic test equipment. A technique of controlled detonation of explosives has been developed to simulate the earthquake ground motions under field conditions, which permits the testing of existing structures. Such developments have permitted rapid progress in our understanding of the behavior of geologic and structural materials, as well as the behavior of engineering structures subjected to seismic loads.

Advancements in computational capability also permit the engineer to analyze and design very complicated structures subjected to complex dynamic loads. Experimental and analytical programs have also provided new insights into the behavior of non-engineered and non-structural components that are often damged in earthquakes.

Of extreme importance in seismic areas is adequate performance of lifelines (gas, water, sewer, communications, transmission lines, highways, etc.) following an earthquake in a metropolitan area. Research has been initiated in these specific areas and already much is now known about coping with potential problems.

A very large percentage of existing structures in seismic areas were constructed before seismic design standards were adopted. Research is investigating procedures for retrofitting and repairing such structures to increase their seismic resistance, and thereby to minimize injuries and loss of life.

Both policy makers and operating units from a range of organizations have benefitted from the useful research on the social and economic aspects of hazard reduction strategies. The results from this research have been used to local, State, and national organizations to improve mitigation and preparedness efforts and to develop disaster warning and post-disaster recovery measures. For example, findings from recent emergency evacuation research supported by NSF have been incorporated into plans devised by local officials in Washington and other states.

This information is also being used by organizations, such as the American National Red Cross, which play a major national role in emergency preparedness and recovery. Similarly, results from NSF-sponsored research on how earthquakes are perceived by the public and on the economic and social factors related to effective mitigation are being used by many responsible organizations. For example, FEMA is incorporating findings from NSF-supported studies in this area in a project to develop an effective program to respond to an earthquake or credible earthquake prediction in southern California. Local, State as well as Federal agencies are participating in this effort which is called the Southern California Earthquake Preparedness and Prediction Project.

In 1969 an NAS Committee, chaired by Dr. George Housner of the California Institute of Technology, conducted a study "Earthquake Engineering Research." The resulting document provided a complete evaluation of the status of earthquake effects mitigation capability at that time and made recommendations for future research. Now, 13 years later, another NAS Committee, again chaired by Dr. Housner, is conducting a similar study to assess the progress that has been made. The results of this study will be available in 1982.

The pressures to constrain Federal budgets have made more important two approaches that have been utilized previously. These are (1) international cooperative projects, and (2) acquisition of data from earthquakes and other natural disasters that occur throughout the world.

International cooperative efforts with countries that share common seismic problems allow the "pooling" of limited resources to solve a particular problem. This has included the acquisition of critical data on ground motion and structural response for major earthquakes in various countries. We are presently in the midst of a very productive project with the Japanese which includes the testing of large-scale reinforced concrete and steel structures in Japan's unique Tuskuba facilities. Other cooperative programs exist in such countries as the People's Republic of China, Taiwan, Indonesia, Italy, and Mexico. We are presently completing arrangements with the Agency for International Development to establish a joint program with the Japanese to assist the third world nations to cope more effectively with earthquake hazards.

A major earthquake anywhere in the world provides a full-scale experiment from which much information can be obtained on the performance of engineering structures and the effects on people. A year ago I reported to this Committee on the success of the studies conducted on the damaging 1979 Imperial Valley Earthquake in California. During the past year, post-disaster teams of engineers and social scientists were dispatched to Algeria, Italy and Greece following major earthquakes. The results are presently being studied to increase the data base for the research and engineering communities.

Other natural disasters have common characteristics with earthquakes. For example, winds, tornadoes, hurricanes and tsunamis may produce dynamic loads on structures similar to earthquake forces, and therefore we attempt to utilize such information. Public reactions to natural disasters have many common elements and thus much can be learned from such events.

New knowledge is being developed at an exciting rate. As I discussed earlier in this testimony, we have had a cooperative research program with the Japanese during the past several years. This has resulted in high quality large experimental facilities being constructed in Japan, and in the short term has allowed the U.S. to move ahead on a global basis in the earthquake engineering field. Over the long term, however, the U.S. must continue to take advantage of new opportunities and invest in facilities that will keep us in the forefront of earthquake engineering, and maintain our strength both in our universities and in industry. To progress even further, we are presently investigating the possibility of utilizing existing experimental facilities in the U.S. for earthquake engineering research, such as the NASA facilities at Huntsville.

Future research activities will emphasize large- and full-scale testing to verify and develop new concepts, the inelastic behavior of structures subjected to seismic loads, special instrument arrays in highly seismic areas of the world, the behavior of "low-rise" structures, and the influence of architectural and urban planning on the vulnerability of structures and communities. We now have available the tools to proceed to the realistic 3-dimensional behavior of engineering materials and structures in an earthquake environment. We will continue to study the impacts of earthquakes on social and economic community systems and develop procedures that will minimize these impacts.

Thank you Mr. Chairman for allowing me to summarize the activities of the Earthquake Hazard Mitigation program in the Engineering Directorate. Significant progress continues to be made in a variety of engineering and social areas and we are directly affecting design and mitigation procedures in seismic parts of the U.S. There is no doubt in my mind that advancements will continue at a rapid rate.

I will be happy to answer any questions that you or members of the Subcommittee may have.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. NASA, through its Geodynamics Program, is experimenting with interferometric techniques for studying crustal dynamics. What seems to be the potential for space-based monitoring for predicting earthquakes? Is NSF exploring any possibilities for monitoring seismic activity from space?

How do U.S. expenditures on earthquake research compare with those of foreign countries?

Answer. The space-based techniques of laser ranging and Very Long Baseline Interferometry (VLBI) have the unique capability to make measurements of crustal deformation over distance of hundreds of kilometers; a range of distances which is inherently inaccessible at centimeter level accuracies using ground based geodetic surveying. The space measurements of crustal deformation thus extend the range of the studies of crustal strain accumulation and release. These studies significantly contribute to basic research in earthquake mechanisms and occurrence. There is no expectation that space measurements alone can be used to predict earthquakes.

NSF is not, at the present time, exploring ways of monitoring seismic activity by NSF use satellite communication links for real time transmission of seismic data. NSF is also a participant in an interagency agreement among NOAA, NASA, USGS, DMA, and NSF for a "Joint Program for the Application of Space Technology to Crustal Dynamics and Earthquake Research." There is also an interagency coordination plan among the same agencies for the "Development and Applications of Astronomic Radio Interferometry for Geophysical Sciences."

Question. (a) How do U.S. expenditures on earthquake research compare with those of foreign countries?

(b) How much of NSF's earthquake funds are being devoted to cooperative programs with foreign countries?

(c) The testimony (Sanderson P. 12) stresses the need for special instrument arrays in highly seismic areas of the world to collect data which should be of vital interest in all countries with high risks of earthquakes. What are the possibilities of joint research and shared funding?

Answer (a). Earthquakes affect many countries of the world and many of these countries have a much more serious problem then the U.S. with respect to the potential frequency of large damaging earthquakes, the percentage of the country subject to relatively frequent strong ground shaking, and the susceptibility of their constructed facilities to damage from such strong ground shaking. Examples of such countries are Japan, China, Yugoslavia, Taiwan, Greece, Turkey, and Algeria. This being the case and considering damage in these countries as compared to that in the U.S., there has been a high incentive for many of these countries to carry on research to deal with these problems. As a result many of these countries have established research facilities and centers to study earthquake engineering problems.

Japan is perhaps the leader in total amount of funds invested in earthquake engineering research and associated facilities. This investment is made by both industry and government but the largest research facilities are government owned and operated. A considerable amount of research in Japan on earthquake engineering is carried on by construction companies. A recent survey indicated that about 65 million dollars per year is spent on earthquake engineering research by construction companies although 46 percent of these funds originate from the government.

Some of the largest testing facilities in the world exist in Japan. Prominent among these are those at Tsukba City where buildings up to 7 stories in height can be tested to full-scale. Another major facility is the 50 Ft. by 50 Ft. shaking table at the nuclear power engineering test center. This facility is rumored to have cost more than 200 million dollars.

In Yugoslavia there are five major laboratories carrying on earthquake engineering research. The most dramatic of these is the new Center for Earthquake Engineering and Engineering Seismology at Skoxje. This center consists of a major testing laboratory with a medium-scale shake table and tie-down-floor and strong-back areas. Three separate additional buildings house computers, library, offices, instrument shops, and small laboratories.

Thus although no definitive amounts are available regarding dollar levels of research activity, they are known to be large and certainly are greater on a per capita basis than what is spent in the U.S. The problem is so vast and important that it is unlikely that any one country could solve the major problems on their own with the resources normally available. This the situation demands cooperation in earthquake engineering between countries.

(b) In fiscal year 1982 the National Science Foundation, on behalf of the U.S., is cooperating with a number of countries on joint research projects. The principal programs are the U.S./Japan Large-Scale Testing Program (the expected expenditure for fiscal year 1982 is approximately $800,000) and the U.S./People's Republic of China Cooperative Earthquake Studies ($250,000 for earthquake engineering and $300,000 for fundamental studies in fiscal year 1982). A number of other minor programs with countries such as Italy, Yugoslavia, etc. have a total expenditure in fiscal year 1982 of $100,000. It should be noted that the expenditures are largely spent in the U.S. on research which is coordinated with activities in the foreign country.

(c) Earthquakes occur as a result of intense and sudden movements below the surface of the earth. Sometimes surface fault movements are observed but the main area where energy is released and propagates out into the surrounding regions is not easily accessible for study. This, coupled with the facts that it usually is not known where and at what time energy will be released along fault systems and that earthquakes are relatively infrequent, makes it difficult to collect information on such phenomena. On the other hand such information is vital if we are to improve our knowledge of earthquake mechanisms, enhance the capability to predict the level of ground motion which will occur at different locations away from the fault, and prepare maps showing zones of different potential levels of intense ground shaking.

Because earthquakes occur in many parts of the world, a joint cooperative effort will greatly enhance the chances of obtaining significant information in a reasonable length of time. In particular, certain areas of the world have a relatively high frequently of strong earthquakes.

This makes it particularly effective for study. If an instrumental array can initially be established, the host country can often assume the maintenance of the array and collection and processing of data.

The possibilities of joint funding with other countries on such activities are very good and in fact this is being done. In fiscal year 1982 for example, strong motion ground arrays are being operated in Taiwan, the People's Republic of China, and India, with both sides sharing the costs. The U.S. has provided the cost of the instruments and the site country, the site itself and its preparation, and the installation, operation, and long-term maintenance of the instruments. Both sides then are able to join in the research and the data processing and analysis. Further opportunities for this kind of activity are continually being sought.

Question. The testimony (Johnson, page 9-11) identifies some important areas where work should be continued or initiated. Which of these should receive highest priority and approximately how much of the fiscal year 1983 request would go for studies in these areas?

Answer. It is difficult to arrange priorities among these items, since NSF responds to unsolicited proposals and also cannot predict where the future breakthroughs will occur. However, if developments occur as we would like, the priorities (in descending order) are as follows with dollar amounts in parenthesis: (a) Studies of seismic sources and slow earthquakes ($1M); (b) inelastic properties of the earth and synthetic seismograms ($1M); (c) investigation of the deep continental lithosphere by COCORP (seismic reflection) and related studies ($3M); (d) distribution of stress in the earth, relationship of earthquake to tectonics and geology ($1M); and (e) Properties of large scale rock masses, and time dependent mechanical properties of rock ($0.75M).

Question. The Committees have received testimony and private communication calling for application of existing knowledge and for increased attention to help state and local governments and various elements of the private sector use research-derived knowledge.

Currently, NSF, USGS, and FEMA are supporting basic and/or applied research activities. What approaches or mechanisms could be used to improve utilization of this knowledge by the state and local government and private sector? Which agency should have lead responsibility for research utilization efforts?

Answer. It is important that significant attention be given to encouraging relevant groups to utilize research supported by NSF and the other agencies in the National Earthquake Hazards Reduction Program. This is being done. For example, this is reflected in the fact that city officials in Los Angeles used research results from NSF supported projects in developing their recently adopted city ordinance for strengthening unreinforced masonry buildings. Utilization can be improved through continued efforts to disseminate research results to users in local and state government as well as those in the private sector. Providing increased technical assistance to local and state officials should also improve utilization. While NSF, USGS, and NBS are mainly responsible for generating useful knowledge and disseminating it to scientists, engineers, and public officials with responsibilities in this area, it would seem appropriate for FEMA to assume the lead role in encouraging the general application of that knowledge by state and local government and the private sector. FEMA is responsible for assisting local and state government in their earthquake preparedness and planning activities, including efforts to utilize existing knowledge. The positive effect that FEMA can have in this regard is shown by the work of the Southern California Earthquake Preparedness Project, which FEMA is involved in through a partnership with local and state government and private organizations.

Question. (a) How do U.S. facilities for earthquake research compare with those of foreign countries engaged in earthquake research?

(b) Can you provide any estimation on the extent of obsolescence of U.S. facilities and instrumentation?

Answer. (a) With respect to seismology, the U.S. is the leader when the entire program is considered, i.e., both theoretical and experimental. The Japanese have excellent electronic gear, computers, and an extensive telemetered (country wide) network. This is not unexpected since they have had a formal earthquake prediction program since 1965. They also have excellent large volume-high pressure presses for lab studies.

China is behind in theory and experimental expertise, but they have many earthquakes and do not lack personnel to observe them. China is making rapid progress and both the U.S. and China will benefit from our cooperative program.

We have little firsthand knowledge of the USSR program. They have some excellent theoreticians but the experimental part of their program probably is weak. Their computers are poor for example. Personnel at the U.S.G.S. have the major cooperative effort with the U.S.S.R. in this area and have first hand knowledge.

With respect to earthquake engineering research, the U.S. has only one shake table (20' x 20') for NSF sponsored research. This is located at the University of California, Berkeley, and is capable of applying a vertical and one horizontal motion. Another smaller table (10' x 10') is at the University of Illinois-Urbana, and has a capability of applying one horizontal force only.

There are several other shake tables in existence in the U.S. One is at Champaign, IL operated by the U.S. Army; six operated by Wyle Labs, a private organization, at Norco, CA. and Huntsville, AL; and two operated by Westinghouse Corporation in Pittsburgh, PA. Only the Berkeley and Illinois tables are currently being used by NSF sponsored projects.

Japan has twenty shake tables of various sizes operated by various agencies of the Government, industry, and universities.

The U.S. facilities available for NSF sponsored research are limited in size and loading capability with only a vertical and/or one horizontal component of loading. In addition, the instrumentation is not as sophisticated or precise compared with the tables in existence or under construction in foreign countries.

Other facilities available for earthquake research are referred to as pseudo-dynamic loading facilities. A small one is located at the University of Texas at Austin and is capable of applying three directions of loading on specimen which is limited to approximately thirty feet in height. There is a test building at the NASA/MSFC which is capable of applying loads in three directions on a large scale specimen with dimensions of 45 x 60 feet in plan and up to 80 to 90 feet in height. However. actuators to apply earthquake loadings would be required. Japan has a strong wall of twenty-five meters (82 ft.) in height capable of applying loads in one direction only.

(b) The shake table at Berkeley is ten years old and one at Illinois is sixteen years old. Both tables are in need of major repairs and replacement of units for the loading system as well as the data recording equipment.

Question. The Engineering Directorate shows an 8.4 percent increase in fiscal year 1983 compared to fiscal year 1982. However, the Earthquake Hazards Mitigation Program is only increased 1.8 percent. Why?

Answer. The Administration places a high priority on the activities funded under the Earthquake Hazards Mitigation Program and, accordingly, funds proposed for fiscal year 1983 are at a slightly increased level over fiscal year 1982. However, fiscal year 1983 is a year of exceptional budgetary constraint. As such, major emphasis has to be placed on those areas which have overriding priorities. Funding levels in the Engineering Directorate reflect this situation: major emphasis is directed at supporting basic research in the various engineering disciplines as well as selected areas in problem focused research. If budget constraints are loosened, additional emphasis in the Earthquake program would of course be a candidate for increased support.

Question. Discuss NSF's outreach and dissemination activities for earthquake research knowledge during fiscal year 1981. How have you interfaced with state and local governments?

Answer. During fiscal year 1981, NSF supported more than a dozen earthquake workshops or conferences. These included a Workshop on Seismic Upgrading of Existing Buildings in California, and a Workshop on Seismic Retrofitting of Buildings in the Puget Sound Area. Officials from state and local government attended many of these conferences, as well as representatives from the private sector. The NSF supported National Information Service for Earthquake Engineering (NISEE) at the University of California, Berkeley and the California Institute of Technology also continued its dissemination activities. NISEE disseminated earthquake engineering and related information through its two libraries, computer codes, and publications, including the Astract Journal in Earthquake Engineering. The principal users of the service include researchers, engineering practitioners, and local and state government officials. The program has also interfaced with state and local governments through the Natural Hazards Information Center at the University of Colorado, and the Hazards Resource Referral Service at the Academy for Contemporary Problems.

In fiscal year 1981, NSF continued to joint fund the Information Center with other Federal agencies such as USGS and FEMA, and continued to joint fund the Referral Service with FEMA. The Information Center continued to strengthen ties and exchange information between the hazard research community and such users as local and state government officials and private practitioners. State and local government officials continued to be the primary users of the Referral Service. The Referral Service served as a clearing house on hazard and disaster information by answering inquiries from officials and distributing information on earthquake and other hazards and disasters.

Question. Should consideration be given to a multi-year authorization for the Earthquake Hazards Reduction Act?

Answer. Two year authorization is favored by NSF and has been supported by the Administration. This longer time horizon for planning will make greater research continuity possible. The biannual authorization should permit adequate adjustment to changing research needs. NSF is always ready, of course, to respond to congressional concerns and meet with committee staff on issues affecting the program.

Question. What progress has been made in research on societal response to earthquakes?

Answer. The Societal Response element of NSF's Earthquake Hazard Mitigation program supports research on the socioeconomic aspects of earthquake mitigation and preparedness, hazard information dissemination, and research on disaster impacts and responses. Significant progress has been made in each of these areas of research. As a result of work supported by NSF on earthquake mitigation and preparedness, important advances have been made in our understanding of the social, political, economic, and legal factors which influence the adoption and implementation of building codes and land-use regulations. Research on this topic which has made important contributions include studies at the University of California, Santa Barbara and at the University of Redlands on seismic safety preparedness in several local jurisdictions in California.

Important advances are also being made in the work supported by NSF on the social aspects of earthquake prediction and warning, which is a sub-area of the dissemination and warning activity. For example, an assessment of the public response to the southern California Uplift, which some scientists thought could be an earthquake precursor, was recently completed at the University of California, Los Angeles. This study identified some of the major social problems, as well as opportunities for hazard reduction, that can be anticipated following future earthquake predictions and warnings. Progress has also been made in investigating disaster impacts and responses in order to produce the requisite knowledge for developing institutional measures that will speed the recovery of communities struck by earthquakes and other disasters. For example, various aspects of disaster relief, rehabilitation, and recovery are being studied by investigators with NSF support at such institutions as Ohio State University's Disaster Research Center. Also, useful studies are being conducted on the impact of earthquakes in other societies, such as the research on the 1976 Guatemala earthquake now being completed at the University of Georgia. Such research is providing new perspectives for understanding our own country's experience with these hazards.

Thus, the Societal Response element is making important progress towards the goal of providing a sounder scientific basis for improving earthquake hazard mitigation, preparedness, and response efforts. Other Federal agencies such as FEMA and state and local officials are utilizing the results of the societal response research. For example, such results are being used by the intergovernmental Southern California Earthquake Preapredness Project in designing earthquake warning and dissemination strategies and an earthquake response management system.

Mr. **Walgren**. Thank you very much, Dr. Sanderson.

Dr. Johnson, your written statement will be made part of the record and please summarize as best you can.

STATEMENT OF DR. FRANCIS JOHNSON, ASSISTANT DIRECTOR FOR ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES, NATIONAL SCIENCE FOUNDATION

Mr. **Johnson**. Thank you, Mr. Walgren.

The primary goal of the NSSF program on fundamental earthquake studies is to acquire an understanding of the fundamentals of the earthquake phenomenon and associated processes. Such an understanding is essential for the eventual prediction of earthquakes and destructive ground motion.

A solid, independent program of fundamental studies will provide the framework upon which more empirical programs of earthquake prediction can be based. Such a framework will help assure that an empirical program is scientifically sound and flexible, will provide direction for the optimal use of resources and, of course, will provide a reservoir of imaginative ideas, new experiments and basic theory that will be required if the particular empirical approach proves inadequate.

Funding for the program has followed option B of the Newmark-Stever report throughout the duration of these guidelines. This year we are funding the program at $7.1 million and in 1983 we expect to fund it at $7.7 million, an 8-percent increase over 1982.

During the past year, the Division of Earth Sciences has been reorganized in the form of eight programs instead of four. The reorganization was made to reflect the increasingly interdisciplinary nature of the Earth sciences, to effect a better management structure, and to increase emphasis on the continental crust.

A feature of the new organizational structure is the increased visibility of seismology and earthquake-related studies. They are the principal components of a program called seismology and deep Earth structure. Seismology and earthquake-related studies have, of course, been of long-term interest to the Earth Sciences Division. They have been a significant part of the Division's program for some 20 years. The importance of the earthquake hazards reduction program to the new seismology and deep Earth structure program is in stressing the research to the concerned scientific community and ensuring good coordination both within that community and with the other Government agencies.

Close coordination among the seismology and deep Earth structure program, the earthquake prediction program of the USGS, and the earthquake research programs of the other agencies is of great importance. This is attained by close personal contacts of the program personnel and by a liaison membership on each other's advisory committees and evaluation committees.

It is not realistic to attempt to predict the outcome of a fundamental research program in terms of technological milestones. Nevertheless, we can reasonably predict that a basic research effort focused on projects with a strong potential for application to the earthquake prediction and hazard reduction program will result in a more comprehensive understanding of the earthquake process. Progress in such basic understanding can be expected to increase the efficiency as well as the reliability of earthquake prediction.

I am very happy to have had the a chance to appear before you.

[The statement follows:]

STATEMENT OF DR. FRANCIS S. JOHNSON, ASSISTANT DIRECTOR FOR ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and Members of The Committee, I am pleased to be here to discuss the fundamental research of the Division of Earth Sciences as it relates to the Earthquake Hazards Reduction Program. Since I spoke to you last Spring the Division of Earth Sciences has been reorganized in the form of eight programs instead of four. The reorganization was made to reflect the increasingly interdisciplinary nature of the earth sciences, to effect a better management structure, and to increase emphasis on the continental crust. A feature of the new organizational structure is the increased visibility of seismology and earthquake related studies. They are the principal components of a new program called Seismology and Deep Earth Structure. Seismology and earthquake related studies have, of course, been of long term interest to the Earth Sciences Division and have been a significant part of the Division's program for some 20 years. The importance of the Earthquake Hazards Reduction Program to the new Seismology and Deep Earth Structure Program is in giving a focus, and stressing the importance of the research to the concerned scientific community, and in ensuring good coordination both within that community and with the other Government agencies.

The primary goal of the NSF Program on Fundamental Earthquake Studies is to acquire a solid understanding of the fundamentals of the earthquake phenomenon and associated processes. Such an understanding is essential for the eventual prediction of earthquakes and destructive ground motion. We feel that a solid independent program of fundamental studies will provide the framework on which more empirical programs of earthquake prediction can be based. Such a framework will help assure that an empirical program is scientifically sound and flexible, will provide direction for the optimal use of resources and, of course, will provide a reservoir of imaginative ideas, new experiments and basic theory that will be required if a particular empirical approach proves inadequate.

The Earth Sciences Division has supported a number of projects to provide the fundamental understanding I have just spoken of. Time does not permit me to go into detail; however, I would like to mention a few highlights to give you a flavor of the kind of research we are doing.

Seismologists at the Lamont-Doherty Observatory of Columbia University have synthesized more than a decade of work on seismic gaps—regions located along plate boundaries that have not experienced earthquakes for a number of years and where stresses between the plates have not been released. The identification of an area as a seismic gap provides a basis for estimating the location and size of future earthquakes; however, the timing the event cannot be specified to better than a few tens of years with this theory at the present time. The seismic potential along all major plate boundaries of the Pacific Ocean and in the Caribbean has been defined and the location and approximate magnitude of at least 13 large earthquakes have been successfully forecast. On the basis of this knowledge, scientists and engineers can concentrate seismic instruments in those areas that appear to be the most likely sites of future shocks, thus concentrating available resources on events that will yield high informational results at lower cost.

Detailed Study of Continental Structure—A consortium of five universities (The Consortium for Continental Reflection Profiling, or COCORP) sponsored by NSF has been examining aspects of crustal deformation in various parts of the country to improve our understanding of earthquakes through more precise definition of the geometry and physical properties of faults. A better understanding of earthquakes that can ultimately lead to their prediction requires not only the identification of active faults but also the creation of more realistic models of subsurface structure to interpret properly related measurements, such as seismic velocity variations, microearthquake distribution, and surface deformations. Those COCORP surveys that map inactive faults also provide new evidence relevant to earthquake activity, since such faults help define the nature and rheology of strain accommodation at all crustal levels and their spatial variation. Seismic reflection profiling under the sponsorship of both the NSF and the USGS has made significant contributions to current understanding of the New Madrid, Missouri and the Charleston, S.C. seismic zones.

Some of the other research topics being pursued with considerable success are: improvement in the understanding of rock mechanics and rock properties as stresses approach the failure point; advances in various types of theoretical modeling of earthquake sources; refinements in the measurement of the size of earthquakes; and development of the capabiltiy to generate synthetic seismograms as an aid to better determination of the seismic source.

I would like to submit a more detailed overview of the program for the record.

Funding for the Program in the AAEO Directorate followed Option B of the guidelines set by the Newmark-Stever Report throughout the duration of these guidelines. This year we are funding the program at $7.1M and in fiscal year 1983 we expect to fund it at $7.7M, an 8 percent increase over fiscal year 1982.

It is not realistic to attempt to predict the outcome of a fundamental research program in terms of "technical milestones." Nevertheless, we can reasonably predict that a basic research effort, focused on projects with a strong potential for application to the earthquake prediction and hazard reduction program, will result in a more comprehensive understanding of the earthquake process. Progress in such basic understanding can be expected to increase the efficiency as well as the reliability of earthquake prediction.

Close coordination among the Seismology and Deep Earth Structure Program, the earthquake prediction program of the USGS, and the earthquake research programs of other agencies is of great importance. This is attained by close personal contacts of Program personnel and by liaison membership on each other's Advisory Committees and Evaluation Committees.

I shall be happy to answer any questions you or members of the Subcommittees may have.

ATTACHMENT

OVERVIEW OF FUNDAMENTAL EARTHQUAKE RESEARCH BY THE NSF DIVISION OF EARTH SCIENCES

1. Major Accomplishments

Plate tectonics

Delineation of "Seismic gaps" and a map of seismic potential for the simple major plate boundaries of the world. (See attached figure.)

Increased knowledge of the nature of subduction zone earthquakes and the physical processes by which they are generated.

Better knowledge and understanding of the state and magnitude of stress in the Earth's lithosphere.

Evidence that most large plate boundary earthquakes are complex multiple shocks that consist of a number of smaller events.

The association of the location of particular intraplate earthquakes with faults and other tectonic features.

The improved delineation and understanding of lateral heterogeneity in the Earth.

The earthquake process

A better understanding of the processes that go on in rocks prior to an earthquake and of the details of the final rupture and energy release.

The introduction of a new, more quantitative measure of the "size" of an earthquake, the moment.

The inversion of seismic data to determine the moment tensor as a function of time—a measure of the temporal pattern of stress release.

The improvement of discrimination between earthquakes and nuclear explosions.

Improved procedures to compute synthetic seismograms.

A better understanding of the dynamic processes of faulting—how a fault rupture nucleates, spreads, and finally stops, and the effects seen in seismograms from each of these three stages in the faulting process.

An increased knowledge of the phenomena that occur on a fault within the zone of crushed material referred to as "gouge."

The discovery that a number of major earthquakes have been preceded by a premonitory clustering of small earthquake events in their epicentral regions.

Research on tilt, magnetic field, resistivity and gas emanation has furnished some suggestive but not universally accepted precursory data.

2. Additional Activities of Special Note

Detailed study of continental structure

The Consortium for Continental Reflection Profiling (COCORP) project is using deep seismic profiling to provide several types of information of importance to the understanding of earthquakes and to the reduction of earthquake hazard.

Ultra long period seismology

A new network of very long period seismographic stations is being established around the world. Data from this network is providing a unique set of high-quality, very long period digital seismic data for a number of new and important studies of the earth. Such data, previously not available, can be used to study the mechanism of earthquakes.

Instrumentation

The needs of geodesists for better benchmarks and for better methods to measure regional deformation, strain and tilt have led to the development of new "state-of-the-art" instruments. Notable among these are: (1) the cryogenic, superconducting gravimeter; (2) the long baseline (about 1 km) laser strain meter; (3) the long baseline (500m) tiltmeter; (4) the two and three color laser geodimeters; and (5) the stable laser interferometric benchmark.

Ocean bottom seismology

Recent developments in ocean bottom seismographs (OBS) have greatly improved both the quality and quantity of data from offshore events.

International cooperation

Significant governmental programs in the area of earthquake prediction and seismic hazard mitigation exist in such countries as Japan and the People's Republic of China (PRC). There continue to be close liaison and cooperation in the area of fundamental studies between the U.S. program and these foreign programs. In particular, there has been recent activity under the protocol for cooperative earthquake studies between the NSF, the USGS, and the State Seismological Bureau of the PRC, which was signed in Beijing in January, 1980.

3. Future Directions

Results from past work have indicated a number of important directions in which research should currently be directed. It is not possible to predict what a fundamental studies program will be in future years. We can only plan to continue and complete the most interesting and promising work currently in progress, realizing that the actual work over the next few years will be guided by major discoveries that emerge, often unpredictably.

We, can, however, list some important areas that must be continued or initiated:

Initiation of new studies and expansion of current effort is needed to investigate the deep continental lithosphere.

The development of reliable ocean-bottom seismometers (OBS) for long term ocean floor recording of seismicity, particularly along ridge crests, fracture zones, and near subduction zones.

More cooperative, interdisciplinary studies are needed at continental margins, particularly in view of the almost certain commercial application to the exploration for gas and oil.

There is a need for an increased understanding of the relationship of earthquakes to tectonics and geology. A better understanding of the distribution of stress in the earth, obtained from surface geodetic and stress measurements and from earthquake studies, may answer some of these questions.

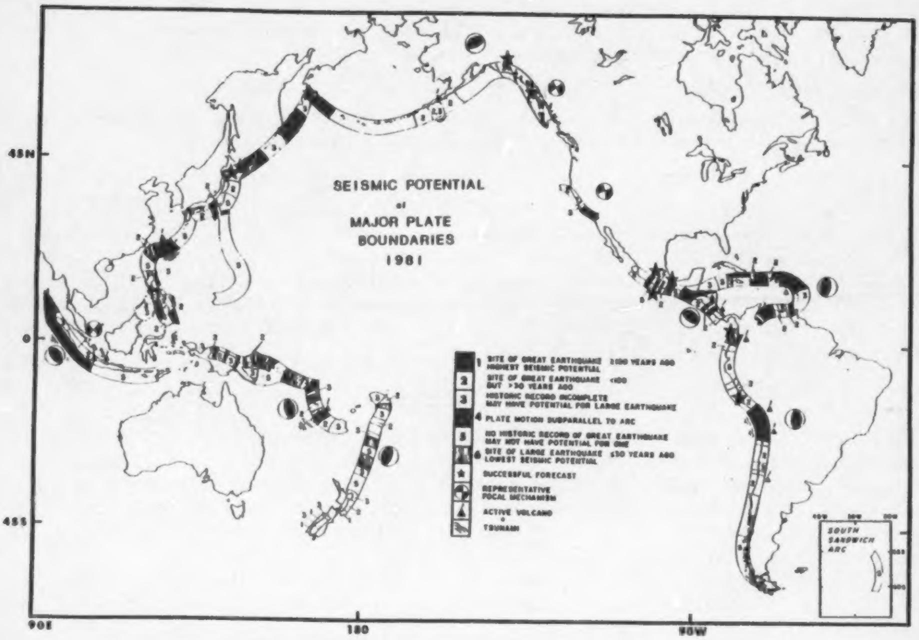
In the past, seismologists were limited to studies of abrupt seismic sources because the existing technology was not sufficiently advanced for study of long term dynamical effects. New instrumentation now allows us to open up the whole important area of dynamical source mechanics, i.e., seismic-source phenomena with very long-term characteristics. At low frequencies, we can study the longer time history of earthquake sources and particularly the hypothesized "slow earthquakes" that may precede the more usual ones with which we are familiar. Continued augmentation of global broadband digital networks is desirable.

Lack of knowledge about the inelastic properties of the earth represents a major gap and is one of the most pressing problems in seismology. In order to determine the structure of the earth from broadband seismic data, it is necessary to incorporate the effects of seismic-wave attenuation. The use of synthetic seismograms in the quantitative study of amplitudes of seismic waves is a recent advance in this area, but further observational, theoretical, and laboratory investigations are needed.

We need to know the properties of the large-scale rock mass, i.e. the rock as it occurs in nature, with its ensemble of joints, fractures and inhomogeneities.

Laboratory studies are needed on the time-dependent mechanical properties of rock since these are poorly understood and may dominate processes at geological strain-rates.

International cooperation in research will be especially important in the near future as seismologists seek ways to predict earthquakes. Opportunities to acquire data and experience related to the prediction of major earthquakes, which are rare events at any one location, are essential to progress. By preparing cooperatively to make observations related to occurrences of strong earthquakes in many parts of the world, the international seismological community can optimize its chances of being in the right place, with the right instrumentation, at the right time, for the benefit of all nations afflicted by earthquake disasters.


SEISMIC POTENTIAL
of
MAJOR PLATE
BOUNDARIES
1981
1 SITE OF GREAT EARTHQUAKE ≥100 YEARS AGO
HIGHEST SEISMIC POTENTIAL
2 SITE OF GREAT EARTHQUAKE <100
BUT >30 YEARS AGO
3 HISTORIC RECORD INCOMPLETE
MAY HAVE POTENTIAL FOR LARGE EARTHQUAKE
4 PLATE MOTION SUBPARALLEL TO ARC
5 NO HISTORIC RECORD OF GREAT EARTHQUAKE
MAY NOT HAVE POTENTIAL FOR ONE
6 SITE OF LARGE EARTHQUAKE ≤30 YEARS AGO
LOWEST SEISMIC POTENTIAL
SUCCESSFUL FORECAST
REPRESENTATIVE
FOCAL MECHANISM
ACTIVE VOLCANO
TSUNAMI
SOUTH
SANDWICH
ARC
45N
0
45S
90E
180
90W

Mr. Walgren. Thank you very much. The last witness on this panel is Dr. John Lyons, who is the Director of the National Engineering Laboratory with the National Bureau of Standards.

Dr. Lyons, your statement will be made, of course, a part of the record. It is good to see you again, and please summarize as you see fit.

STATEMENT OF DR. JOHN LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS

Mr. Lyons. Thank you, Mr. Chairman.

I did appear before the House Subcommittee on Science, Research and Technology on both February 9 and February 10. At that time I testified on the programs of the National Engineering Laboratory broadly and also specifically on both our fire and earthquake efforts.

I brought with me today Dr. Richard Wright, the Director of the Center for Building Technology, who is charged specifically with responsibility at the Bureau for our earthquake effort. Not only do we request, as you indicated, incorporation of my written statement in the record, but also I would like Dr. Wright's written statement to be incorporated in the record.

Mr. Walgren. Without objection, it will be done.

Please pull the mike just a little bit closer so those in the back of the room can hear.

Mr. Lyons. There is not room at the table for Dr. Wright, but he is immediately to my left. I think he is hiding.

We have been involved in the Federal Government's earthquake programs for many years. Since 1969, the Bureau has served as U.S. cochairman of the U.S.-Japan Panel on Natural Resources, the subpanel on wind and seismic effects. We are still serving as co-chairman of that effort. Dr. Sanderson mentioned the current large-scale structural test work underway in Japan, funded by the National Science Foundation. That work is conducted under the subpanel.

We too conduct field investigations. I would cite five—the San Fernando quake in 1971, the one in Managua in 1972, the one in Romania in 1977, one in Japan in 1978, and one in Imperial County, Calif., in 1979. We have been working on tentative provisions for seismic regulations for buildings with both public and private sector groups and made a report on that in 1978.

At that time a new program in earthquake disaster mitigation was enacted and a new effort begun. Our role at the Bureau in this new program is to provide technical support in the development of seismic design and construction provisions for buildings and to conduct research in support of that activity.

The Interagency Council on Seismic Safety in Construction has as its vice chairman, Dr. Wright, who is at the moment also the acting chairman. In 1981 draft seismic standards for Federal buildings were submitted to that council by the Bureau.

The Building Seismic Safety Council, formed in 1979, is a private group that the Bureau helped to form. In the year 1981 we submitted 11 technical reports to the BSSC on tentative provisions for use in trial designs for seismic-resistant buildings. The research at the Bureau of Standards in support of these activities is both in foundation studies, in areas such as soil liquifaction, and in seismic resistance of masonry structures.

The Bureau's direct funding of $425,000 was upped to $475,000 for fiscal year 1982, and the same is budgeted for fiscal year 1983. We are asking that this amount be reauthorized for fiscal year 1983. In addition to those funds we received reimbursements from FEMA for work averaging about $200,000 over the last several years, and we expect, based on discussions with FEMA, that level of support will continue.

As to the technical details of our work, Dr. Wright's written statement has a rather lengthy summary both in the statement itself and in the appended summaries of technical reports. He and I would both be pleased to answer any questions that you may have.

[The statements follow:]

STATEMENT OF DR. JOHN W. LYONS, DIRECTOR, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS

INTRODUCTION

Mr. Chairmen and Members of the Subcommittees: I am pleased to be here today to discuss the earthquake hazard reduction activities at the National Bureau of Standards.

On February 9th, I had the pleasure of appearing, with Dr. Ambler, Director of the National Bureau of Standards, before the House Subcommittee on Science, Research and Technology to describe the highlights of the activities, accomplishments, and plans for the National Engineering Laboratory at NBS. On February 10th, before the same Subcommittee, I described our fire research program and our work on earthquake hazard reduction.

The earthquake hazard reduction activities at the NBS are conducted primarily by the Center for Building Technology of the National Engineering Laboratory. Dr. Richard N. Wright, Director of the Center for Building Technology, is accompanying me today, and will be available to answer questions. With permission of the Chair we would like to submit for the record a written statement by Dr. Wright detailing the earthquake hazard reduction activities at NBS.

EARTHQUAKE HAZARD REDUCTION ACTIVITIES

NBS has a long-time involvement in research activities related to improved seismic design and construction. In 1969 we assisted the State Department in establishing a Subpanel on Wind and Seismic Effects of the U.S.-Japan Panel on Natural Resources and, to date, NBS serves as the U.S. co-chairman. An important U.S.-Japan program on large-scale structural testing is conducted under the auspices of this Subpanel with U.S. funding from NSF.

To ascertain needs for improved seismic design and construction and for research in this area, we investigated damaging earthquakes such as San Fernando, 1971; Managua, 1972; Romania, 1977; Miyagi-ken-oki, 1978; and Imperial County, 1979. We worked in cooperation with other Federal agencies and the Earthquake Engineering Research Institute. With NSF and the the Applied Technology Council, we published Tentative Provisions for the Development of Seismic Regulations for Buildings in 1978. The publication synthesizes up-to-date design provisions from research findings. A copy of that publication is available to the Subcommittees, if you would like to have it.

Our Center for Building Technology has a specified role in the National Earthquake Hazards Reduction Program, established in 1978 in response to Public Law No. 95-124, the Earthquake Hazards Reduction Act of 1977. We are called upon to provide technical support in the development of seismic design and construction provisions for buildings in private and public sector and to conduct research on performance criteria and supporting measurement technology.

The Interagency Committee on Seismic Safety in Construction (ICSSC) was formed in 1978 under FEMA auspices to develop guidelines to assist Federal agencies involved in construction in reducing earthquake hazards. From the inception of the ICSSC, we have provided technical support. Dr. Wright is the Vice Chairman, and is currently serving as the Acting Chairman. NBS also serves as charmen for two of the ten subcommittees. In 1981, we published the Draft Seismic Standard for Federal Buildings called for in the National Earthquake Hazards Reduction Program which was developed by an ICSSC Subcommittee chaired by the NBS.

Working with FEMA, we assisted in the formation of the Building Seismic Safety Council (BSSC) in 1979. The purpose of BSSC was to provide a national forum to foster improved seismic safety provisions for the design, construction and use of buildings. The BSSC has about 60 members from the private sector, with only one Federal member representing the ICSSC. We provided technical support to the BSSC and participated in technical committees composed of representatives of private and public sector organizations. In 1981, we published eleven reports for BSSC. The reports reviewed and refined the tentative seismic provisions for use in trial building designs which provided BSSC with the basis for developing recommended seismic provisions. We also provided technical support for, and reported to BSSC on, the plan for the trial building design program in 1981.

Our earthquake research is addressing the development of measurement and test methods to ascertain the potential for soil liquefaction in earthquakes and of a means to predict the strength and energy-absorbing capacity of masonry structures in earthquakes.

The fiscal year 1982 and projected fiscal year 1983 funding level for the NBS earthquake program totals approximately $675,000 each year from all sources. For fiscal year 1983 $475,000 is included in the NBS appropriations request. This money will support our research on soil liquefaction and behavior of masonry walls. FEMA funding of somewhat over $200,000 each year is passed-thru to NBS to support our work on the development of seismic design and construction provisions for private and public buildings. Based upon preliminary discussions with FEMA we are hopeful that this level of support will continue.

This completes my written statement. Dr. Wright and I will be pleased to answer any questions you may have.

STATEMENT OF RICHARD N. WRIGHT, DIRECTOR, CENTER FOR BUILDING TECHNOLOGY, NATIONAL ENGINEERING LABORATORY, NATIONAL BUREAU OF STANDARDS

INTRODUCTION

I am Richard N. Wright, Director of the Center for Building Technology, National Engineering Laboratory, NBS. I would like to discuss the earthquake hazard reduction activities at the National Bureau of Standards (NBS). These activities are conducted primarily by the Center for Building Technology of the National Engineering Laboratory and are an integral part of the NBS building research program. The overall program examines all aspects of the building design, construction, and use. Principal thrusts of the building research program include: (1) developing improved criteria and standards for the performance of all building elements (structures, mechanical, space, etc.), (2) developing improved measurement technology and test methods for the performance of building attributes (e.g., materials, durability, acoustics, safety, lighting, solar energy systems, etc.), and (3) improving the efficiency of building use, including energy.

NBS has a long-time involvement in research activities related to improved seismic design and construction. In 1969 we assisted the State Department in establishing a Subpanel on Wind and Seismic Effects of the U.S.-Japan Panel on Natural Resources and, to date, we have provided the U.S. co-chairman. An important U.S.-Japan program on large-scale structural testing is conducted under the auspices of this Subpanel with U.S. funding from NSF.

To ascertain needs for improved seismic design and construction and for research in this area, we investigated damaging earthquakes such as San Fernando, 1971; Managua, 1972; Romania, 1977; Miyagi-ken-oki, 1978; and Imperial County, 1979. We worked in cooperation with other Federal agencies and the Earthquake Engineering Research Institute. With NSF and the Applied Technology Council, we published Tentative Provisions for the Development of Seismic Regulations for Buildings in 1978. The publication synthesizes up-to-date design provisions from recent research findings.

NATIONAL BUREAU OF STANDARDS ROLE IN THE EARTHQUAKE HAZARDS REDUCTION PROGRAM

The June 22, 1978, National Earthquake Hazards Reduction Program (NEHRP) which resulted from the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) assigned NBS the following continuing responsibilities.

Provide technical support to the building community, including the Federal agencies involved in construction, "in continuing the development, testing, and improvement of model seismic design and construction provisions suitable for incorporation in local codes, standards (including Federal standards), and practices."

Perform "research on performance criteria and supporting measurement technology for earthquake resistant construction."

The major thrusts of the NBS earthquake program include: (1) safety evaluation of existing buildings, (2) improved design criteria and standards, (3) post disaster investigations, and (4) more reliable measures of the effects of natural forces on buildings. The work involves interdisciplinary research and problem solving by structural, geotechnical, materials, mechanical and electrical engineers; architects; and economists. Analytical, laboratory, and field research is conducted in cooperation with other government agencies, practicing engineers and architects, professional organizations, trade associations, building owners, products manufacturers, standards and regulatory organizations, and university researchers.

In planning this work close liaison is maintained with individuals and organizations in both the public and private sectors. These interactions assist in identifying and assigning priorities to research problems in earthquake engineering. They also insure that NBS efforts are coordinated with work carried out by other organizations.

NBS has worked closely with FEMA in exercising its lead agency responsibility for coordinating the National Earthquake Program. This work included establishment of the Interagency Committee on Seismic Safety in Construction and participation in its activities, establishment of the Building Seismic Safety Council and participation in its activities, and participation, with others, in the review and planning of earthquake-related Federal research.

The Interagency Committee on Seismic Safety in Construction (ICSSC) was formed in 1978 under FEMA auspices to develop guidelines to assist Federal agencies involved in construction in reducing earthquake hazards. From the inception of the ICSSC, we have provided technical support. Currently, we provide the Vice Chairman, who is now Acting Chairman, and the chairmen of two of the ten subcommittees. In 1981, we published the Draft Seismic Standard for Federal Buildings called for in the National Earthquake Hazards Reduction Program which was developed by an ICSSC Subcommittee chaired by the NBS.

NBS, FEMA and concerned groups of the building community worked together to help establish the Building Seismic Safety Council (BSSC) in April 1979. The purpose of BSSC is to provide a national forum to foster improved seismic safety provisions. The Council's objective is to promote the development of seismic provisions suitable for use throughout the United States. In this effort, the Council's first specific task was to review the Tentative Provisions for the Development of Seismic Regulations for Buildings that were developed in an NBS-Applied Technology Council projected funded by NSF and NBS.

At the request of the BSSC, the National Bureau of Standards has provided technical studies for this review. With financial support from FEMA, we called together and worked with approximately 50 organizations from throughout the U.S. to review the Tentative Provisions in order to develop an improved document. In 1981, we published 1 reports for BSSC. The reports reviewed and refined the tentative seismic provisions for use in trial building designs which provided BSSC with the basis for developing recommended seismic provisions. We also provided technical support for, and reported to BSSC on, the plan for the trial building design program in 1981.

The success of Federal programs for achieving earthquake hazards reduction can be measured in terms of the extent to which the results are used by various mission agencies and private sector building owners and users and the extent to which the results are incorporated in new standards and improved design practices. The working relationships that NBS has established with groups throughout the building community provide an effective means for achieving this implementation. NBS building research staff participate actively in standards development in the private sector as well as at the Federal, State and local levels; over all the CBT programs, 67 different staff members participate in 270 distinct standardization activities. We also provide technical assessments of proposed building code provisions that are closely related to our technical programs. These efforts result in adoption of the findings of our research in standards and codes. For example, NBS serves as secretariat of the American National Standards Institute Committee A58, responsible for developing the voluntary consensus standard entitled, "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures." This National standard for design loads, including earthquake, is currently undergoing revision.

In preparing the various working documents for the ICSSC Subcommittee on Building Standards, we drew upon our experience in earthquake hazards reduction, including participation in development of the Tentative Provisions, analysis of those Provisions through a research project, preparation of a plan for evaluation of those Provisions and the subsequent participation in the joint NBS/BSSC project to review the Provisions. This background helped to prepare a better Federal document, one that in its future revisions will be easier to revise for consistency with private sector codes and standards.

EARTHQUAKE RESEARCH PROGRAM

The primary objectives of the NBS research contribution to the earthquake program are:

Research for standards.—Improve building design and construction practices by conducting fundamental research necessary to establish consistent standards that include reliable measures of the performance of buildings and their environment during an earthquake.

Standards development.—Provide technical support in the "Development of Seismic Design in Construction Standards for Consideration and Subsequent Application in Federal Construction and Encouragement for the Adoption of Improved Seismic Provisions in State and Local Building Codes."

These two objectives provide the input into two National problem areas: 1) safe and economical new construction and 2) effective reduction of existing hazards.

Safe and economical new construction

It is important that new construction not add to the earthquake problem. Safe and economical new construction may be achieved by improved nationally applicable standards for new buildings. Structural, geotechnical, mechanical, architectural and economic studies supported by the NSF over the past seven years, have provided substantial advances in abilities to model and predict the earthquake response of various built elements and their consequences. This knowledge must be synthesized to develop design criteria that will provide consistent safety among the various built elements and various materials or technologies for each. Moreover, design criteria must be developed to fit methodologies appropriate to the responsible design profession. Evaluation and measurement methods consistent with practices of design, manufacture, construction and inspection must be developed to implement the design criteria. Our work with the BSSC and ICSSC is aimed at helping to fill these needs.

Effective reduction of existing hazards

Existing hazardous buildings are perhaps the greatest source of danger to the population during a severe earthquake. It is necessary to develop techniques to identify the most hazardous buildings, to develop nondestructive methods to determine the properties of the buildings and their components inplace, and to define the strength and energy-absorbing capacity provided by techniques of strengthening and repair.

Development of seismic design provisions for consensus standards and model codes as well as Federal building construction is a key element in this program. This current fiscal year we have started to work with the ICSSC in this area of existing hazardous buildings.

ACCOMPLISHMENT IN FISCAL YEAR 1981

NBS efforts in fiscal year 1981 resulted in completing five significant milestones. For the ICSSC, we prepared (1) the report "Draft Seismic Standard for Federal Buildings" for trial implementation. These draft provisions were called for in the NEHRP.

In the work associated with the Building Seismic Safety Council, we prepared (2) the series of reports which recommended the changes to the Tentative Provisions for the Development of Seismic Regulations for Buildings. In establishing the committee structure for review of the Tentative Provisions, members of the ICSSC were included in order to link with the work of the Building Seismic Safety Council. Thus, the ICSSC will be prepared to use BSSC results in future Federal seismic provisons. We also provided technical support for preparing (3) a "Draft Plan for a Trial Design Program to Assess the Tentative Provisions for the Development of Seismic Regulations for Buildings."

NBS serving as co-chairman, and through its participation on the U.S.-Japan Panel on Wind and Seismic Effects of the U.S.-Japan Program on Natural Resources and working with NSF has created the environment in which the two countries are currently conducting a cooperative program on large-scale structural research under the auspices of the UJNR. With U.S. funding from NSF research is now underway in Japan on (4) steel structures and will begin shortly in the U.S. Research on (5) the seismic resistance of reinforced concrete structures is nearing completion.

Our earthquake research is addressing the development of measurement and test methods to ascertain the potential for soil liquefaction in earthquakes and of means to predict the strength and energy-absorbing capacity of masonry structures in earthquakes.

CLOSURE

I have included a list of some of our accomplishments in the areas I have described in Attachment A for your information.

The NBS considers our earthquakes engineering research important in the development of safe and economical buildings. We plan to continue working with FEMA in meeting our responsibilities in the NEHRP.

This concludes my formal statement. I would be pleased to answer any questions you may have.

ATTACHMENT A

ACCOMPLISHMENTS [1]

Earthquake investigations

Briefed House Committee on Public Works on the damage caused by the San Fernando Earthquake of February 9, 1971 and documented building performance. (OEP, DoD, NBS)

Lew, H. S., Dikkers, R. D., Leyendecker, E. V., Pfrang, E. O. and Kramer, S., NBSIR-10556, "The San Fernando California Earthquake of February 9, 1971," 1971.

Lew, H. S., Leyendecker, E. V., and Dikkers, R. D., BSS-40, "Engineering Aspects of the 1971 San Fernando Earthquake," 1971.

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[1] Organizations providing funding for each activity are indicated in parenthesis.

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Made recommendations to the Nicaraguan government for the repair of severely damaged buildings. Conducted investigation at the request of the State Department of building damage caused by the 1972 Managua Earthquake. (USAID, NBS)

Wright, R. N. and Kramer, S., TN 807, "Building Performance in the 1972 Managua Earthquake," 1973.

Conducted an investigation at the request of the State Department of building damage caused by the March 4, 1977 Romania Earthquake. Made recommendations to the State Department for the expenditure of U.S. funds provided to Romania for reconstruction following the earthquake.

Fattal, S. G., Simiu, E., and Culver, C., SP 490, "Observations on the Behavior of Buildings in the Romania Earthquake of March 4, 1977," 1977.

Conducted an investigation of the Miyagi-ken-oki, Japan Earthquake of June 12, 1978 in cooperation with the FHWA, USGS, and EERI. (Earthquake Engineering Research Institute) (NBS)

Ellingwood, B., Editor, SP 592, "An Investigation of the Miyagi-ken-oki, Japan Earthquake of June 12, 1978," 1980.

Conducted a survey of damage caused by the 1979 Imperial County Earthquake in cooperation with the Earthquake Engineering Research Institute and contributed to EERI publication. (NBS)

"Reconnaissance Report—Imperial County, California, Earthquake, October 15, 1979," 1980.

Research and development program planning

Worked with building community representatives and university researchers in a 1972 workshop to identify policies and priorities for improvement of building practices for disaster mitigation. (NSF, NBS)

Wright, R. N. Kramer, S., and Culver, C., Editors, BSS 46, "Building Practices for Disaster Mitigation," 1973.

Worked with design professionals and university researchers to identify research needs for earthquake resistant masonry construction based on a national workshop. (NSF, NBS)

Crist, R. and Cattaneo, L., Editors, BSS 106, "Earthquake Resistant Masonry Construction: National Workshop," 1977.

Worked with design professionals and university researchers and identified research needs and priorities for geotechnical engineering based on a national workshop. (NSF)

Lee, K. L., Marcuson, W. F., Stokoe, K. H., and Yokel, F. Y., Editors, Report, "Research Needs and Priorities for Geotechnical Earthquake Engineering Applications," 1978.

Worked with the OSTP in establishing the Building Seismic Safety Council in 1978 to foster improved seismic safety. The BSSC consists of representatives of organizations that will promulgate, use, or be affected by seismic design standards. (NBS)

Working with FEMA, NSF, and USGS, NBS participated in drafting in 1979 a Seismic Research Plan for 1981-1984. This effort, conducted under the auspices of the OSTP, was intended to assure a coordinated approach in the research efforts of the four agencies. (NBS)

Worked with university and private researchers in 1979 to develop a recommended cooperative U.S.-Japan research program to be conducted under the auspices of the U.S.-Japan Panel on Natural Resources. NSF currently is funding a Cooperative U.S.-Japan Program in Large-Scale Structural Testing as a result of the joint effort. The program was extended in 1981. (NBS)

Liaison member of NRC Committee on Earthquake Engineering Research in 1982 to review state of such research in the U.S. (NBS)

Studies for standards

Developed criteria for use by the Veterans Administration in evaluating the strength of unreinforced masonry in existing buildings for the purpose of determining their seismic resistance. This program was a result of the San Fernando Earthquake experience. (VA, NBS)

Fattal, S. G. and Cattaneo, L. E., NBSIR 75-520, "Evaluation of Structural Properties of Masonry in Existing Buildings," 1974.

Developed procedures for use the Defense Civil Preparedness Agency for the evaluation of risks due to natural hazards in existing buildings. (DCPA)

Culver, C. G., Lew, H. S., and Hart, G. C., BSS 61, "Natural Hazards Evaluation of Existing Buildings," 1975.

Developed recommendations for improving the building regulatory system to the government of Nicaragua. This was a result of the experience in the 1972 Managua Earthquake. (USAID, OAD)

Wright, R. N. and Lamana, A., TN 885, "A Technical Review of the Nicaraguan Building Regulatory System," 1975.

Evaluated seismic design criteria, at the request of the Federal Energy Regulatory Commission, proposed for use in liquified natural gas facilities planned for California. Started in 1977 and continuing. (FERC)

Worked with design professionals and university researchers and developed tentative seismic design provisions incorporating the latest research results of NSF, NBS, and USGS. (NSF, NBS)

NBS participated in the technical study to develop a trial design plan to evaluate the "Tentative Provisions."

"Draft Plan for a Trial Design Program to Assess the Tentative Provisions for the Development of Seismic Regulations for Buildings," Letter Report, August 1981.

NBS serves as the Secretariat of American National Standards Institute's A59 "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures." This national standard for design loads (earthquake, wind, gravity, etc.) is a major vehicle for implementing research in work into the private sector.

Laboratory research (numerous reports available, some recent samples are listed)

Yokel, F. Y., Chung, R. M., and Yancey, C. W., "NBS Studies on Mobile Home Foundations," NBSIR 81-2238, March 1981.

Kovacs, W. D., Salomone, L. A., and Yokel, F. Y., "Energy Measurement in the Standard Penetration Test," National Bureau of Standards, BSS Report No. 135.

Kovacs, W. D. and Salomone, L. A., "SPT Hammer Energy Measurement," submitted May 1981 to ASCE Journal of the Geotechnical Engineering Division for possible publication (copy available).

Kovacs, W. D., "Results and Interpretation of SPT Practice Study," ASTM Geotechnical Testing Journal, September 1981.

Dobry, R., Ladd, R. S., Yokel, F. Y., Chung, R. M., and Powell, D., "Prediction of Pore Water Pressure Buildup and Liquefaction During Earthquakes by the Cyclic Strain Method," National Bureau of Standards, BSS 138, Report.

Dobry, R., Powell, D., Yokel, F. Y., and Ladd, R. S., "Liquefaction Potential of Saturated Sand—The Stiffness Method," Seventh World Conference on Earthquake Engineering, Istanbul, Turkey, October 1980.

Dobry, R., Yokel, F. Y., and Ladd, R. S., "Liquefaction Potential of Overconsolidated Sands in Moderately Seismic Areas," to be published in the Knoxville Conference on Earthquakes and Earthquake Engineering of the Eastern U. S., September 1981.

Applied Technology Council, SP 510, "Tentative Provisions for the Development of Seismic Regulations for Buildings," 1978.

Worked with standard and code users and developed a program plan to facilitate implementation of the seismic design provisions described in SP 510 through model codes, voluntary standards, and regulatory groups at the Federal, State, and local level. This includes a plan to evaluate the impact of the tentative provisions of SP 510 prior to any implementation. (NSF)

Culver, C. G. and others, NBSIR 78-1549, "Plan for the Assessment and Implementation of Seismic Design Provisions for Buildings, 1978.

Developed techniques and performed systematic study of the logic and the internal consistency of seismic design provisions of SP 510. (NSF, NBS)

Harris, J. R., Fenves, S. J., and Wright, R. N., TN 1100, "Analysis of Tentative Seismic Design Provisions for Buildings," 1979.

Participate as part of the Interagency Committee on Seismic Safety in Construction which includes most of the Federal agencies. CBT provides the vice-chairman and acting chairman of the ICSSC. CBT serves on its Steering Committee, chairs two subcommittees and participates in four others. One of these, the subcommittee on Building Standards, is charged with developing uniform Federal provisions for seismic design. (NBS, FEMA)

Harris, J. R., Leyendecker, E. V., and others, NBSIR 81-2195, "Draft Seismic Standard for Federal Buildings," 1981.

NBS is conducting technical studies of "Tentative Provisions for the Development of Seismic Regulations for Buildings," in cooperation with the Building Seismic Safety Council (formed by FEMA, NBS, and others). This effort will lead to provisions that have been broadly reviewed and that will be used as the basis for conducting trial designs for the purpose of impact assessment.

NBSIR 80-2111-1 through 11, "Review and Refinement of ATC 3-06 Tentative Seismic Provisions," a series of eleven reports reviewing specific areas of ATC 3-06, 1980.

Professional activities (selected examples)

Established through the State Department, a joint U.S.-Japan group in earthquake effects (U.S.-Japan Panel on Natural Resources, UJNR, subpanel on Wind and Seismic Effects) in 1969 in order to begin coordination of efforts of the two countries. NBS provides the chairman of the U.S. subpanel. (NBS)

Technical arm of National Conference of States on Building Codes and Standards.

[The following information was subsequently received for the record:]

U.S. Department of Commerce,
National Bureau of Standards,
Washington, D.C., April 7, 1982.

Hon. Harrison H. Schmitt,
U.S. Senate,
Washington, D.C.

Dear Senator Schmitt: It was a pleasure to appear before you and the members of the Science, Technology and Space Subcommittee of the Commerce, Science and Transportation Committee and the House Science and Technology Committee on March 11, 1982.

I have prepared the attached response to your letter of March 19, 1982. I am prepared to meet with you or your staff to furnish additional information if required.

As we have noted in our meetings, we would be glad to have you, other members of the Committee, or staff visit us to see the research activities currently underway at NBS. Your continued interest in our programs is greatly appreciated.

Sincerely,

John W. Lyons,
Director, National Engineering Laboratory.

Enclosure.

Question 1. If the current level of Federal effort is maintained how long will it probably take to get codes and construction practices widely adopted to minimize seismic hazards? What might be done to speed up the adoptive process?

Answer. Generally speaking, the voluntary codes and standards related to building construction are on a three-year revision cycle. The voluntary standards, which serve as the basis of the model codes, consider design loads (including earthquakes) or a specific type of construction (such as reinforced concrete, structural steel, or masonry) but do not cover both. Since state-of-the-art seismic design must include not only the load but also the response of specific construction types to those loads, the various standards must be coordinated in order to achieve consistency and equality among the various construction types in terms of safety and cost. For example, the one national loading standard "Building Code Requirements for Minimum Design Loads in Buildings and Other Structures" published by the American National Standards Institute has recently completed a revision cycle. One material construction type, reinforced concrete, is nearing completion of its proposed draft for publication in 1983. Thus a minimum of three years is normally required to get changes incorporated in codes.

A report "Tentative Provisions for the Development of Seismic Regulations for Buildings" containing recommendations for consideration by codes and standards groups was developed as part of a cooperative effort between the National Science Foundation and NBS using the Applied Technology Council as a principal resource. Although it has been available since mid-1978, trial designs called for by the design profession prior to code adoption of the provisions have not been made. Such designs would evaluate the economic effect of adopting the provisions. There will continue to be reluctance to adopt the recommendations in this report until the trial designs have been completed.

Question 2. What progress has been made in developing and adopting seismic design and construction standards?

Answer. With NSF and the Applied Technology Council, NBS published "Tentative Provisions for the Development of Seismic Regulations for Buildings (Tentative Provisions)" in 1978. The publication synthesizes up-to-date design provisions from recent research findings.

The American National Standards Institute Committee, publishes the voluntary consensus standard entitled, "Building Code Requirements for Minimum Design

Loads in Buildings and Other Structures" described in response to question 1 above. A revision to this National standard for design loads, including earthquake, was approved by the Board of Standards Reviews on March 10, 1982. This revision incorporates many of the Tentative Provisions recommendations for earthquake loads which are applicable to all construction materials.

NBS, FEMA and concerned groups of the building community worked together to help establish the Building Seismic Safety Council (BSSC) in April 1979. The purpose of BSSC is to provide a national forum to foster improved seismic safety provisions. In this effort, the Council's first specific task was to review the Tentative Provisions.

At the request of the BSSC, the National Bureau of Standards provided technical studies for the review. With financial support from FEMA, NBS called together and worked with approximately 50 organizations from throughout the U.S. to review the Tentative Provisions in order to develop an improved document. In 1981, we published 11 reports for BSSC which contained the results of the review and refinement study and recommended modifications. NBS also provided technical support for, and reported to BSSC on, a plan for the trial building design program in 1981. Upon completion of the trial design program the BSSC will revise and publish the findings which will serve as a resource document for the voluntary codes and standards groups.

Recommendations for Federal construction, "Draft Seismic Standard for Federal Buildings," were prepared for the Interagency Committee on Seismic Safety in Construction which was established under the NEHRP. These recommendations are under consideration by Federal agencies participating in the ICSSC.

Question 3. What was your actual budget for fiscal year 81 and fiscal year 82?

Answer. The funding for the NBS earthquake program since 1979 is shown below. We receive appropriations of $425,000 for the program and spent that amount in each of fiscal years 1979, 1980, 1981. For fiscal year 1982 our appropriation for the program was increased to $475,000; we plan to spend that amount. FEMA funding of somewhat over $200,000 each year has been provided to NBS to support our work on the development of siesmic design and construction provisions for private and public buildings. We are hopeful that this level of support will continue.

NBS AND FEMA FUNDING OF EARTHQUAKE ENGINEERING AND RESEARCH PROGRAM AT NBS

[In thousands of dollars]

	1979	1980	1981	1982	1983
NBS funds	425	425	425	475	[1] 475
FEMA funds	[2] 481		[2] 430		

[1] The amount shown is included in fiscal year 1983 budget request.

[2] Funds received late in fiscal year. Activities supported in subsequent fiscal years with carryover funds.

Question 4. In fiscal year 1981, how much funding was received from FEMA and when was this funding given to NBS?

Answer. NBS received from FEMA $401 K on September 30, 1981 and also received on September 30, 1980, $29 K for fiscal year 81 expenditures.

Question 5. What are the priorities of the earthquake program at NBS?

Answer. The National Bureau of Standards has a principal role in the National Earthquake Hazards Reduction Program, established in 1978 in response to Pub. L. No. 95-124, The Earthquake Hazards Reduction Act of 1977. The NBS is responsible for (1) technical support in the development of siesmic design and construction provisions for private and public sector buildings and for (2) research on performance criteria and supporting measurement technology. Funding for technical support for the development of standards generally has been budgeted by FEMA, while funding for research is in the DOC budget.

NBS feels that the highest priority in the NEHRP should be given to the development and implementation of cost effective earthquake hazard reduction practices for buildings and lifelines. Adequate design and construction standards and codes are essential for these practices. NBS priorities for the research funded within the DoC budget are for applied research which can serve to improve or fill technical needs in codes and standards. Specifically the NBS earthquake research is addressing the development of measurement and test methods to determine the potential for soil liquefaction in earthquakes and means to predict the strength and energy absorbing capacity of masonry structures in earthquakes.

We are currently addressing new building problems but plan to deal with existing buildings as our program evolves.

Mr. **WALGREN**. Thank you very much, Dr. Lyons.

Let me then turn to Senator Schmitt for any questions.

Senator **SCHMITT**. If you gentlemen do not mind, I presume you already announced we are going to follow a 5-minute rule so everybody has a chance.

Mr. **WALGREN**. Fine.

Senator **SCHMITT**. That is what we normally do here.

Mr. **WALGREN**. Whatever the ground rules——

Senator **SCHMITT**. That is the only way you can keep me under control.

Mr. **WALGREN**. I might have to yield some time to Mr. Brown under that circumstance, but that is OK. I am just thinking it is hard to keep him under 5 minutes.

Senator **SCHMITT**. Well, he and I have been together on many panels. We share equal blame, I think, with that problem.

Gentlemen, do you agree that there is a potential in several populated areas in the United States for tens of thousands of casualties at any moment as a result of a sizable earthquake?

You can all nod your head up and down if you wish.

[Witnesses nodding in the affirmative.]

Senator **SCHMITT**. You would all acknowledge that that danger exists.

Then, given that danger, what would be our response if such a thing happened? Pick an example—Southern California, San Francisco, some big city in the Midwest, Boston.

Mr. **THOMAS**. Senator, I represent FEMA and I will attempt to respond to that question first.

As I indicated in my statement there are response plans in place for Federal agency response, particularly, for instance, in portions of California. In other parts of the country there are response plans in place, but they are not specific to earthquakes.

One of the major efforts we have under way in FEMA at this time is insuring that there is a overall specific response plan—a national response plan—that would be in place and that would have the detailed operating procedures for each of the designated Federal agencies that would have to respond to support State and local government at any place in the country where there was a major catastrophic earthquake.

It is an area that I am particularly concerned about within FEMA in that I am also responsible for disaster relief and emergency response and would be the individual that would be responding for that agency with our resources. This is one area to which we have given a particular high priority.

Senator **SCHMITT**. Has there ever been a simulation of this response? Have you ever exercised those plans?

Mr. **THOMAS**. There was an exercise of the response plan in the San Francisco area.

Senator **SCHMITT**. How did it work? What did you do? What was the first thing you did? Big earthquake in San Francisco, 8.6—that has happened before—on the Richter scale. What was the first thing you did in that plan?

Mr. THOMAS. The 6th Army is well prepared. Most other Federal agencies need to improve their preparedness posture. I do not have more specific details.

Senator SCHMITT. But you just said you were in charge. My God, I would hope you would know. What do you do, pull it off the shelf and start to read it after the earthquakes occur?

Mr. THOMAS. No, sir. I can tell you what at this point in time would be the first step as far as response is concerned at the national level. Through our Emergency Information and Coordination Center we would contact with all the Federal agencies that would be called upon to respond with us and move forward to provide the assistance that was requested from State and local government. The response——

Senator SCHMITT. But local government has no communications with State or Federal in the instant. They do not. I think it is safe to say there would be no radio—long distance radio anyway—or telephone communications out of the area affected.

Mr. THOMAS. Recognizing that——

Senator SCHMITT. A few CB's might be in operation.

Mr. THOMAS. Yes, sir. Recognizing that, I think that that situation is the reason for trying to have inplace and developed now the operating plans that the Federal agencies would use so that when the earthquake occurs, they would begin moving with the assumption that assistance would be required because of what had taken place.

Senator SCHMITT. And you have requested what, $3.1 million this year in this budget?

Mr. THOMAS. Yes, sir.

Let me point out that response planning in our agency is generic in the sense that we are involved in developing response plans and carry out responses to fixed nuclear facilities incidents, fixed nuclear weapons accidents, and a variety of natural disasters on a continuing basis.

What I am working on now in my response planning unit is trying to insure that we have a specific response plan for catastrophic earthquakes. But the financial support for response planning comes from several sources and is broader than the earthquake hazards reduction program.

Senator SCHMITT. Well, let me try a different tack. Let's say that due to the fantastic research efforts of the U.S. Geological Survey and the National Science Foundation and the private sector, universities, colleges, seismological laboratories, there is in place right now—let us assume there is in place a prediction system that provides a series of precursors that all reasonable people, including Dallas Peck, decide is pointing toward an earthquake within a fairly narrow time frame somewhere out in the future.

Have you thought of any way to utilize that information in a major populated area?

Mr. THOMAS. A major component of the southern California project which we have not discussed is doing just that, developing a prediction response plan and public awareness programs on earthquake prediction. That is a major component of that project, to develop specific plans as to how to use that information for response and for information to the public.

Senator SCHMITT. When can we expect to know that that is in place and that everybody at the local level who needs to know knows and has exercised it and is ready to move?

Mr. THOMAS. This fiscal year and next fiscal year we are anticipating products out of the southern California project that will be applicable both to that area as well as available to transfer to other parts of the country. We expect specific products in that area, in fiscal year 1983.

Senator SCHMITT. And if you are wrong the first time, how do you handle it the second time?

Mr. THOMAS. Hopefully better than the first time.

Senator SCHMITT. But will anybody believe you?

Mr. THOMAS. That is a major consideration that has to be incorporated into any kind of emergency response to a prediction. It is a major consideration, for instance, in our planning for nuclear war.

Senator SCHMITT. But doesn't that mean that you need to have a far better public information system than exists today, which is practically nonexistent? I do not recall in my few visits to Los Angeles listening to the radio or anything else and hearing any detailed discussion of this problem.

Mr. THOMAS. I would certainly agree with you.

Senator SCHMITT. My time is up. We will get back to it in a moment.

Mr. WALGREN. Thank you, Senator Schmitt. We will have several rounds. It seems when we group witnesses together as a panel they get all the time. That is not really fair.

Mr. Brown.

Mr. BROWN. Gentlemen, one of the questions that we are looking at is whether we should reauthorize this act for 1, 2, or a longer-year period. Is there a consensus or disagreement with the idea of a 2-year reauthorization from any of you? Two years seems to be the best?

[Witnesses nodding in the affirmative.]

Mr. BROWN. Let me ask you, Mr. Thomas, there are certain types of earthquake hazard recovery planning that are probably generic, that is, non-site-specific. I am thinking specifically of planning for the financing of major operations. Let me pose the possibility of something like the projected, say, $40 billion loss in the event of a major earthquake in the southern California area. Let us assume that half of it is covered by insurance.

What would be the plans, if any, or should we have plans for planning the reconstruction and meeting that additional $20 billion gap? Is there any source of Federal funding or any plans to provide sources for financing of the recovery operations?

Mr. THOMAS. That has been the subject of several analyses. One that you are probably familiar with and was completed recently in draft concerns the potential for earthquake insurance and the Federal role, if any.

Several alternatives were brought forward in that report, as a matter of fact, to deal with that problem. The study also represents quite an analysis of the kind of economic catastrophe a major earthquake would be, particularly in southern California.

The current laws would provide for limited relief under the Disaster Relief Act to take care of immediate assistance to the victims.

The figure you have used, though, for instance, $20 billion, far surpasses any kind of disaster that we have had under that particular act. Mount St. Helens, for instance, was nowhere near anything like that, so it was covered under that particular Act. But other than that specific piece of legislation now, I know of no other financial assistance other than a separate appropriation by Congress that would be available.

We are reviewing the report on subsidization for earthquake insurance to look at some of the alternatives that were presented and see if the administration should propose any kind of legislation in this area.

Mr. BROWN. I do not recall that I have seen that report and I think that I would like to look at it, if you could provide that.

Mr. THOMAS. I would be glad to.[1]

Mr. BROWN. Or at least may I ask if the staff does not have a copy that they get one from you, so that I can review it.

Dr. Peck, one of the things that has concerned me has been occasional reports that we have not been able to maintain the stability of the breadth of monitoring that you refer to in your own statement as necessary to provide the data base here. What is the current situation with regard to that?

Dr. PECK. Our budget for this activity and the budget for the whole earthquake program has been relatively constant at about $32 million a year since 1980 through 1982. We have been maintaining and building up that network and increasing our ability to measure various geophysical phenomena.

Now we are looking forward to fiscal year 1983. There is about a 10 percent cut in the budget of the earthquake program and a number of other programs in the Department of the Interior, but our intent is to look at theoretical and laboratory studies to bear most of the burden of that cut, and about the last thing that we would cut is our monitoring networks.

We are looking at our network of seismographs throughout California and elsewhere to see whether some stations can be cut out without degrading the data that we receive. Most of the cut will not be taken in monitoring stations.

Mr. BROWN. Does that mean that you have an adequate monitoring system in place?

Dr. PECK. We have an adequate monitoring system for research efforts. As I explained in my statement, we do not have a fully operational, operating 24-hours-a-day sort of hardwired system as part of a warning network. We are still trying to learn how to predict earthquakes and it is premature to make the investment in funds and manpower at this time for such a system.

Mr. BROWN. But you have indicated in your statement that you need a history of monitoring x number of major earthquakes in order to be able to do this prediction.

Dr. PECK. That is right. We are augmenting our study of the United States by programs around the world and we have a major cooperative program with the PRC, with China, in order to extend our knowledge of earthquake occurrence.

Mr. WALGREN. Thank you, Mr. Brown.

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[1] The report has been received and is in the committee files.

Mr. Dymally.

Mr. **Dymally**. Thank you, Mr. Chairman. This question is for any one of the panelists, although I suspect it might be FEMA's responsibility.

Senator Schmitt talked about the question of public apathy. Do you have any plans for dissemination of information to the public—regional conferences, university and college involvement in this whole discussion for public preparedness?

Mr. **Thomas**. One of the elements of the southern California project is a public information and public education component. We are planning and working to develop a public education program as part of that project that we would then be able to use not only in that particular area but in other areas of California and around the country.

We also have had, as was mentioned earlier, for instance, in some of our other projects, the one in the Central United States, the one in the Northeast, public education components, but these have been more from a point of view of what the hazard is in the particular area, as we have done in the vulnerability analysis portion of a project. They are not the kind of structured public education program we are talking about in the California project but information on what the project is about,

Mr. **Dymally**. Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Mr. Dymally.

Let me ask Dr. Sanderson, in your testimony you indicate that we are pursing research with respect to the performance of lifelines, transmission lines. I guess that is communications and gas and the like. It is so hard to know what is behind the words.

You know, I listen and I know that that is an important thing to do, but can you give some life to that for me in some way? What kind of research? What do we have to show for it that we can actually go and say to people, look, we are doing something concrete that is valuable?

Dr. **Sanderson**. Mr. Chairman, there are several projects in this area that I would like to report to you for the record. I would point now to one we are funding with the University of Oklahoma, a project looking at the seismic performance of buried pipelines—an important type of lifeline.

For more than 2 years, projects have been underway at RPI, the University of Notre Dame, and others, looking at the properties of buried cables, buried pipes, buried communication facilities, and the way that typical construction would respond in a major seismic event.

Mr. **Walgren**. Now when we say a program goes on, how would we describe the program? Is that a check written out to Rensselaer Polytechnic Institute? Do you know how many hours of what level of return do you get?

Dr. **Sanderson**. Yes. I would be glad to supply it for you. The project at Oklahoma involves both laboratory and field experiments to measure the seismic response characteristics. It involves actually getting people out into the field and the laboratory experiments to complement some analytic programs.

Some of the activities at RPI, I believe, are more analytic in nature, attempting to build a model of the way an underground pipeline is constructed and to predict the way it would respond to typical seismic shock waves.

Mr. **Walgren**. Is there anything that would do more than describe the problem? I mean, the research comes back and says it broke.

Dr. **Sanderson**. No. I think the research tells us more than the fact that it broke. It will tell us what broke and why it broke and therefore would give us very good indications about ways to build it so that it would not break.

Mr. **Walgren**. Do we have a way of directing ourselves toward that second question, or do we just file the information in a book and put it in the library distribution system and it is just out there for interested parties?

Dr. **Sanderson**. No. Most of the earthquake researchers feel acutely the need not just to understand why things went wrong or why things would go wrong, but to understnd ways to make sure that things do not go wrong in the future.

Mr. **Walgren**. Does the National Science Foundation have a way of asking that second question as a matter of procedure instead of relying on the interests of most of the people out there in the field that are so interested?

Dr. **Sanderson**. Yes. In each of the projects, we certainly look at the ability to improve seismic safety. That is the stated mission of the program.

More than that, we sponsor a number of workshops and seminars each year, bringing our researchers together with the users, the engineers responsible for actually constructing facilities. We put them in a room together and let them talk.

Your question implies—and I am not sure that I would agree—that there may be a certain theoretical attribute to our university research community. In fact, the researchers are in the room and talking with the persons responsible for putting construction in the field. That tends to go a long way toward encouraging reality and asking how do you make it work as opposed to trying intellectually to understand why it goes wrong.

Mr. **Walgren**. Thank you very much. In my second round I would like to address the same question to Dr. Lyons with respect to the seismic design and construction business, but I have run out of time now and I will get back on the second round.

Senator Schmitt.

Senator **Schmitt**. Thank you, Mr. Chairman. I asked this question in 1977 and I will ask it again. I have never been satisfied with the answer.

Why, Dr. Peck, don't we get down to the business of building a prototype predictive system in a high-risk area or even in two or three high-risk areas so that we force people who are doing the research—whether it is engineering or science—to begin to apply that research to actually doing something, to building something, not with any commitment that we will be able to predict an earthquake but that we begin to build the capability to make that commitment?

Dr. **Peck**. Dr. John Filson, head of our office of earthquake studies, is in the room. He has been giving some thought to designing and starting the planning of the prototype system and certainly within the next few years we should. I agree with you.

With the present budgetary climate, however, this——

Senator SCHMITT. Well, with the present budgetary climate, the present administration emphasis, you know, there are priorities and priorities. I am sure I could go through the budget and find some things that I think will affect people short and long term a lot less than the next major earthquake is going to affect them.

It has been my experience in the space program and in other activities that until you force people to start to try to apply what they are doing research on, it is just so much paperwork. It is interesting and it is nice to go to meetings and talk about them. I suspect earthquake hazard conferences in sections of GSA and AGU and others are very intriguing and stimulating. But they are not getting down to the business of how do you apply this to a prototype system and then use that prototype system as the basis for simulations of FEMA's ability and the local government's ability to respond.

You know, once you have that system in place you can put signals into it to exercise the team.

Dr. PECK. We are moving in that direction. The introduction of the two-color laser geodometer for strain measurements, with measurements every day, and an increase in the monitoring effort in southern California is part of the effort. We are getting together on a periodic basis in southern California and reviewing all the strain information, sort of facing up to all the seismic strain information, the radon monitoring and so on, to focus attention on facing up to the problems.

So it is not all just going to meetings. We are moving in that direction, Senator.

Senator SCHMITT. I am a great fan of archeology. But I suspect that there is a lot more money going into archeological mitigation in dealing with the leasing activity under the jurisdiction of the Department of the Interior and USGS at this time than there is going into the mitigation of hazards for earthquakes.

Am I not correct?

Dr. PECK. There is a fair effort going on under the Minerals Management Service.

Senator SCHMITT. That is right, the new effort. And somehow or another it boggles my mind that we cannot find the resources necessary to begin to move toward understanding how to put together a predictive system and then, in turn, using that system as a way to force Mr. Thomas in his operation, his plans, to learn how to handle a major disaster of this kind.

Again, I am a hands-on type of geologist and spaceman, I guess, and I just think we would be much farther along if we had directed our efforts into the development of prototypes and I think we have been in a position to do that. We know an awful lot about precursors to earthquakes. We do not know as much as we would like, and we may not know as much as we feel is necessary to make a good prediction, but we know an awful lot and successful predictions have been made elsewhere in the world.

Dr. PECK. Yes. Part of the problem is that some precursors seem to work in some areas for some faults and not for others.

Senator **Schmitt**. Well, that is why I say you may want more than one prototype but let's do not wait around until somebody decides to give us enough resources to have 50 prototypes before we build the first one.

I still am concerned that one of the reasons we have not been more active here, we do not know what to do with the information and I think that is a very dangerous position to put ourselves in, because we are not going to learn what to do with the information until we start getting some information.

Dr. **Peck**. This activity, the emergency mobilization planning board in southern California is another step in forcing us to move in that direction.

Senator **Schmitt**. Thank you, Mr. Chairman.

Mr. **Walgren**. Thank you, Senator Schmitt. Mr. Brown.

Mr. **Brown**. Dr. Peck, you have indicated you are taking a 10-percent cut in your budget in this area and while you have put a good face on this reduction and indicated that you do not think it will drastically affect the efforts being made there, I am also concerned that you have had, if I am not incorrect, some additional responsibilities placed on you. I will not put this as a question, but I would just express concern, as Senator Schmitt has, that you may not be adequately funded in this budget for the scope of activities that may be necessary here.

I have one additional question I would like to pose to you. You have made reference to a conference in Los Angeles on May 4 and 5 involving largely the private sector. Could you give me some idea as to the auspices under which this conference is being called and whether or not it indicates increased participation and interest by the private sector in participating in this overall program?

Dr. **Peck**. If I could, Congressman, and Chairman, could I call Dr. Filson to the podium because I am not very well informed on that?

Dr. **Filson**. My name is John Filson. I am the Chief of the Office of Earthquake Studies at the Geological Survey.

I believe the conference you are referring to is being held in Los Angeles about the 4th and 5th of May.

It is being organized by an individual who works for Atlantic Richfield, and I understand that this is an independent activity on behalf of industry, being led by the Atlantic Richfield Corp. to bring the industrial decisionmakers together and make them aware of the earthquake hazard and what steps can be taken to mitigate that hazard in the southern California area.

I am not directly aware of the thinking or planning that went into the organization of this conference. We have been asked to participate, speak at the conference, explain our knowledge, the current status of the various disciplines involved and we have agreed to do so.

I must say we look upon this as a fairly positive step on the part of industry becoming active in this area.

Mr. **Brown**. Thank you. I have no further questions.

Mr. **Walgren**. Mr. Dymally?

Mr. **Dymally**. No questions.

Senator **Schmitt**. We will have to go to the next panel shortly. We will have other questions for the record.

Gentlemen, let me, however, ask if there are any significant resources going into the experimentation with seismic monitoring, strain monitoring from space, particularly those activities at JPL that I have heard something about? Dr. Peck, do you have any familiarity with that, or Dr. Sanderson, maybe?

Dr. PECK. Well, we have people here from NASA who are involved in the VLBI—very long base interferometry

Senator SCHMITT. Interferometry? Would somebody want to quickly tell us the status of that effort?

Mr. JACKSON. Professor Jackson, UCLA. We are using—there are in the works two separate schemes for measuring distances from one point to another over long baselines and these would be very valuable in supplementing the shorter baseline work over, say, 15 miles that is carried out by the U.S. Geological Survey to better monitor strain buildup in California or throughout the world and also to monitor plate motions.

The activity is now in very much of a research stage. We are verifying the ability of the systems to actually measure accurately enough to give useful information. We anticipate within a year or so the accuracy will be verified and the systems will then become operational and become a part of an integrated system in the monitoring of the cross dimensions.

Senator SCHMITT. Thank you.

Dr. Peck, if we were to begin to place a significant prototype system without any commitment to prediction but a prototype system based on the research done to date, do you have any idea what one of those would cost? Obviously it would be site-dependent in terms of cost, but do you have a rough estimate of what it would cost to put into place and the amount of time it would take to do that?

Dr. FILSON. Could I respond to that, please?

Senator SCHMITT. Yes, please.

Dr. FILSON. We have given some rough thought to this question and made some rough calculations. We would guess that deploying a system with robust communication links, standardized instrumentation at 50 or so sites in California, sites very well developed with holes being drilled to get away from the surfacial effects, it would cost on the order of $50 million.

Senator SCHMITT. Would that include the active monitoring of observers of other types of precursor information?

Dr. FILSON. No, sir. Most of that money would be in the capitalization in the equipment and the active monitoring would be a small fraction of that effort, but that would be a recurring annual cost.

I must point out, Senator Schmitt—could I continue along this line?

Senator SCHMITT. Please do.

Dr. FILSON. In fact, as Dr. Peck pointed out, we are doing extensive monitoring in California at this time. This data is being brought together at central locations in Menlo Park and in Pasadena. The data is displayed and reviewed regularly. So it is not that we are ignoring our responsibilities of earthquake prediction.

What we point out, though, is that many of these data are collected in rather rudimentary forms, for example, the measurement of radon content in groundwater, which has been useful in predicting previous earthquakes. At some of our sites this information is gathered automatically and transmitted to a center in Pasadena. At other sites someone gets in a Jeep, drives out to a well, collects the water, brings it back to our laboratory and 2 weeks later we know the results.

We are evolving toward a prototype prediction system and we are actively trying to use the data available to us to predict, but there are several aspects of the current system, such as I have just described with the radon measurements, that could be improved with first class or up-to-date instrumentation and robust communication.

Senator SCHMITT. Dr. Thomas, if we had a major earthquake such as I described in my first question in southern California, what do you think would be the administration's proposals following that earthquake? Is that what it is going to take to get us to move in this area?

Mr. THOMAS. No, sir. I don't think so. I think that there is a considerable amount of effort underway now.

Senator SCHMITT. You have testified to that effect. What you consider a considerable amount of effort, there may be some disagreement on that.

With several tens of thousands of deaths and 100,000 or more casualties in southern California, what do you think realistically is going to be the response? Are we just going to go on with business as usual, or is that going to wake us up to do something more substantial, more realistic in terms of earthquake prediction and mitigation?

Mr. THOMAS. We take care of immediate needs. For long-range recovery, personally I think the response would be, as after most major catastrophies, immediate proposals from the administration for additional actions to be taken, probably similar to some of the things you have already heard about today, except on a much enhanced level.

Senator SCHMITT. So in order to get those proposals coming forward from the administration and the priorities sorted out between this and other types of activities in FEMA or elsewhere, it is going to take, potentially, the deaths of tens of thousands of Americans?

Mr. THOMAS. No, sir. We believe that the proposals we have made for fiscal year 1983, coupled with the proposals we have made under our other authorizations will allow us to improve our capabilities. In the response planning that you have highlighted, for instance, we are doing exactly what you are talking about.

We are proceeding with local units of government to develop prototypical response plans, and also developing specific response plans for Federal agencies. In addition, we have held field exercises of some of those plans. We are making progress along several lines.

Senator SCHMITT. So you are doing as much as could be done, even in the aftermath of a major earthquake in a populated area?

Mr. THOMAS. I feel at this point in time, particularly given the fact that I am drawing resources from other authorizations than the funding under the earthquake hazards reduction program, that I am moving to get those plans in place as fast as I can, because I believe that a catastrophic earthquake may happen on my watch.

Senator **Schmitt**. The probability is quite high that it is going to happen on your watch. Quite frankly, from what I have heard and what I know, it is not your fault necessarily, but I do not think we are prepared, and I just do not think we have in place the mechanism to respond.

I congratulate you for trying, and wish you well in your efforts, but every year I have been in the Congress it has been the same story, and we are not much farther along, except we have more information from the research community. But we do not have much in terms of how we are going to make good use of that information and I do not think the request of the administration shows a commitment to that and particularly when we look at what they said last year in September, that they wanted to cut the USGS prediction research program in half, which Congress did not allow, it does not show a commitment of this administration any more than any other administration to do something about this.

We very much are waiting for that big earthquake to happen before we try to do anything.

Mr. **Dymally**. May I ask one question?

Senator **Schmitt**. Sure. I have gone over my time.

Mr. **Dymally**. What are your priorities in terms of your earthquake program at the National Bureau of Standards?

Mr. **Wright**. Our priorities in the area of developing earthquake hazards reduction practices are to provide technical support for the Building Seismic Safety Council in order to have earthquake-resistant design and construction practices and have those abilities available as soon as possible.

In the area of safety of Federal facilities, again, our priorities are to provide as much technical support as resources permit to the Interagency Committee on Seismic Safety in Construction so that the Federal agencies can adopt sensible practices for lifelines, for existing Federal buildings, and for new Federal buildings.

Mr. **Dymally**. Thank you.

Senator **Schmitt**. Congressman Brown, shall we move on to the next panel?

Thank you, gentlemen. We have numerous questions for the record. We appreciate your time and consideration.

Our next panel are outside witnesses. If you would come forward, please, Dr. Charles Thiel, of Woodward-Clyde Consultants; Mr. Donald Pinkerton, executive director, National Conference of States on Building Codes and Standards; Supervisor Cal McElwain, supervisor of the Second District in San Bernardino, Calif.; and Mr. Delbert Ward, Structural Facilties, Inc., Salt Lake City, Utah.

I understand we do have a travel difficulty with Mr. Pinkerton. If the other members of the panel will permit me, I will allow you to go first, and if there are any specific questions that we might want to direct to you before you go, we will do that also.

STATEMENT OF DONALD PINKERTON, EXECUTIVE DIRECTOR, NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

Mr. PINKERTON. Thank you very much, gentlemen. I thank my colleagues for allowing me to have the opportunity to present my testimony before theirs.

Mr. Chairman, my testimony today is going to come from a different angle. While I have appreciation for my colleagues before me who spoke regarding lifelines and systems in place regarding reaction, I would like to talk about our concerns in making new building construction and existing buildings much more safe so that perhaps we do not incur or we perhaps would not need as much reaction to the action.

Mr. Chairman and members of the committee, I am Don Pinkerton, executive director of the National Conference of States on Building Codes and Standards. I wish to thank you for the opportunity to appear before the committee and to address the concerns of our organization with respect to the role of the Federal Government on the subject of seismic safety in new and existing buildings.

The conference is a nonprofit corporation whose principal objectives are to foster increased interstate cooperation and to coordinate intergovernmental reforms in the area of building codes. We were formed in 1967 and provide a national forum for discussing issues and concerns on building codes, regulations, and public safety. We have a delegate body comprised of one member from each of the 50 States who have broad-based responsibility for outlining safety codes at the State level and for the most part our membership are, indeed, appointed by their respective Governors.

We are also an executive branch organization of the National Governors' Association and as such provide technical information in health and life safety codes in the area of new and existing buildings. The NCSBCS has established a professional working relationship with the National Conference of State Legislatures and the Council of State Community Affairs Agencies, providing technical information to those organizations as well.

Finally, the conference serves as the secretariat to an organization known as the Association of Major City Building Officials, an organization which is comprised of the 31 largest cities in this Nation.

The purpose of the Earthquake Hazards Reduction Act of 1977 is to reduce the risks of life loss and property destruction from future earthquakes in the United States. Since the inception of Public Law 95–124, the conference has been an active participant with agencies of the Federal Government having responsibility under this act. In addition, by virtue of my position with the conference, I sit as an active member of the board of directors of the Building Seismic Safety Council representing State governments.

Shortly after the enactment of Public Law 95-124, a flurry of activity took place in order to carry out the objectives contained within that act. Those activities included such things as the development of the national earthquake hazards reduction program. We as an organization met on numerous occasions with individuals responsible for the development and implementation of that program.

In addition there was the establishment of an Interagency Committee on Seismic Safety in Construction for Federal programs and also the establishment of the Building Seismic Safety Council, which was formed in 1979 as a nonprofit organization comprised of representatives of the public and private sector whose purpose is to enhance the public safety by providing a national forum to foster improved seismic safety provisions for use by the building community.

In order to achieve this purpose, the Building Seismic Safety Council has as one of its primary objectives to promote development of seismic safety provisions suitable for use throughout the United States.

In 1979 the Building Seismic Safety Council requested that the National Bureau of Standards assist in the review and refinement of the Applied Technology Council's tentative seismic provisions. The request of the Building Seismic Safety Council was immediately responded to by the National Bureau of Standards in a very positive manner. A review and refinement project was planned by NBS with the advice and approval of the Building Seismic Safety Council. Nine technical committees were formed, comprised of representatives of organizations that had a particular interest in the Applied Technology Council's tentative provisions.

Each of the committees was charged with reviewing the tentative provisions which were later balloted upon all members of the Building Seismic Safety Council. In essence then, Mr. Chairman, we now have available a consensus document as it relates to new building construction that awaits the conducting of trial designs.

In order to carry out the required work contained within the National Earthquake Hazards Reduction Program, the Building Seismic Safety Council submitted a proposal to FEMA in 1980 in the amount of $1,503,958, which was broken down as follows: for administrative and operating costs, some $515,000; for the conducting of trial designs, some $988,000.

Funding for the BSSC activities through contracts with FEMA has been somewhat less than encouraging. I make this statement based upon experience in dealing with staff members under the previous and current administrations. I am sure that we all appreciate that it takes time to identify and meet with all the various persons involved in seismic safety at FEMA. Just when we had accomplished that objective, we had a new admiministration in Washington and had to renew our efforts all over again.

In my opinion, the issue of earthquake mitigation within FEMA, unfortunately, is not very high on their priority list as far as funding and personnel are concerned. To date, the BSSC has received $231,584 of its original request of over $1.5 million. However, it would also be fair to point out that just yesterday a representative of FEMA called me and indicated that they are now very serious about funding our trial designs and perhaps they came about because of the committee's interest in this subject, Mr. Chairman.

The interest on the part of FEMA on the subject of earthquakes seemed to wane about 2 years ago as Federal deficit budget considerations were being reviewed in the prior administration and the concept has carried over to the present administration.

On the other hand, I think it is important to underscore the contributions by the members of the BSSC—and by that I mean the private and public members of that organization—and their technical commitments and participation on technical committees in the area of personal hours and travel expenses far exceeds the Federal contribution to this effort.

How much longer the private and public members of the Building Seismic Safety Council will be able to actively participate is questionable if we do not soon see a greater commitment on the part of the Federal agencies to support our efforts as originally conceived.

As I previously indicated, a consensus document now exists and is ready for trial design, but there is no firm commitment by FEMA in this area due to the lack of resources. I believe and would strongly urge that the BSSC funding request be granted so that we may get on with the job of improving new building construction as it relates to seismic safety.

The BSSC efforts have slipped by 2 years, first in that funding was not available for the fiscal year 1981 effort and, second, in that thus far this fiscal year the funding for the conducting of trial designs is still uncertain.

Mr. **WALGREN**. I am sorry to interrupt, but I do want to keep the hearing really rolling. Let me ask for 1 more minute to let you summarize.

Mr. **PINKERTON**. I would just like to emphasize and try to gain your appreciation for the funding for the Building Seismic Safety Council and the work that the National Bureau of Standards is doing in this area. There are some other recommendations contained within my report to you, and I would be pleased to discuss those any time you may find it convenient to discuss them.

[The statement follows:]

STATEMENT OF DONALD F. PINKERTON, EXECUTIVE DIRECTOR, NATIONAL CONFERENCE OF STATES ON BUILDING CODES AND STANDARDS, INC.

Mr. Chairman and members of the Committee on Science and Technology, I am Donald Pinkerton, Executive Director of the National Conference of States on Building Codes and Standards, Inc. (NCSBCS).

I certainly wish to thank you for the opportunity to appear before this Committee and to address the concerns of the Conference with respect to the role of the federal government on the subject of seismic safety in new and existing buildings.

The National Conference of States on Building Codes and Standards is a nonprofit corporation whose principle objectives are to foster increased interstate cooperation and to coordinate intergovernmental reforms in the area of building codes. Formed in 1967, the Conference provides a national forum for discussing issues and concerns on building codes, regulations, and public safety. Its delegate body is comprised of one representative from each of the 50 states and several territories appointed by their respective governors.

The Conference provides states, manufacturers, organizations and individuals with an effective voice in activities of national standards-generating organizations and the federal government.

NCSBCS is an Executive Branch Organization of the National Governors' Association (NGA) and as such, provides technical information on health and life safety codes in the area of new and existing buildings. Moreover, the Conference has established professional working relationships with the National Conference of State Legislatures (NCSL) and the Council of State Community Affairs Agencies (COSCAA) providing technical information to those organizations as well.

Finally, NCSBCS serves as the Secretariat to the Association of Major City Building Officials (AMCBO), an organization comprised of the thirty-one largest cities in our Nation.

The purpose of the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) is to reduce the risks of life loss and property destruction from future earthquakes in the United States.

Since the inception of Public Law 95-124, NCSBCS has been an active participant with agencies of the federal government having responsibilities under the Act. In addition, and by virtue of my position with the Conference, I sit as an active member on the Board of Direction of the Building Seismic Safety Council (BSSC) representing state governments.

Shortly after the enactment of Public Law 95-124, a flurry of activity took place in order to carry out the objectives contained therein. These activities included such things as—

The development of the National Earthquake Hazards Reduction Program (under the Executive Office of the President). NCSBCS met on numerous occasions with the individuals responsible for the development and implementation of the program.

The establishment of an Interagency Committee on Seismic Safety in Construction (ICSSC) for federal program.

The establishment of the Building Seismic Safety Council (BSSC) in 1979 as a non-profit organization comprised of representatives of the public and private sector whose purpose is to enhance the public's safety by providing a national forum to foster improved seismic safety provisions for use by the building community.

In order to achieve its purpose, the BSSC has as one of its primary objectives to "promote the development of seismic safety provisions suitable for use throughout the United States."

In 1979, the BSSC requested that the National Bureau of Standards (NBS) assist in the review and refinement of the Applied Technology Council's 3-06 Tentative Seismic Provisions.

The request of the BSSC was immediately responded to by the NBS in a very positive manner. A review and refinement project was planned by NBS with the advice and approval of the BSSC. Nine technical committees were formed comprised of representatives of organizations that had a particular interest in the Applied Technology Council's Tentative Provisions (NBSIR 80-2111-11).

Each of the committees were charged with reviewing the Tentative Provisions which were later balloted upon by all members of the BSSC. In essence then, we now have available a consensus document that awaits the conducting of trial designs.

In order to carry out the required work contained within the National Earthquake Hazards Reduction Program, the BSSC submitted a proposal to FEMA in 1980 in the amount of $1,503,958 which was broken down as follows: administrative and operations $515,958; the conducting of comparative trial designs $988,000. Funding for the BSSC activities, through contracts with the FEMA, has been somewhat less than encouraging. I make this statement based upon experience in dealing with staff members under the previous and current administrations. I am sure that we all appreciate that it takes time to identify and meet with all of the various persons involved in seismic safety at the FEMA. Just when we had accomplished that objective, we had a new administration in Washington and had to renew our efforts. In my opinion, the issue of earthquake mitigation within FEMA, unfortunately, is not very high on their priorty list as far as funding and personnel are concerned. To date, the BSSC has received $231,584 of its original request of $1,500,000.

The interest on the part of the FEMA on the subject of earthquakes seemed to wain about two years ago as federal deficit budget considerations were being reviewed in the prior administration and the concept has carried over to the present administration.

On the other hand, the contributions by the members of the BSSC and the technical committees (person hours and travel expenses) far exceeds the federal contribution to this effort.

How much longer the private and public members of the BSSC will be able to actively participate is questionable if we do not soon see a greater commitment on the part of the federal agencies to support our efforts as originally conceived.

As I previously indicated, a consensus document now exists and is ready for trial design use but there is no firm commitment by FEMA in this area due to the lack of resources. I believe and would strongly urge that the BSSC funding request be granted so that we may get on with the job of improving new building construction as it relates to seismic safety. The BSSC efforts have slipped by two years; first in that funding was not available for the fiscal year 1981 effort and second in that thus far this fiscal year the funding for the conducting of trial designs is still uncertain. Once that this trial design effort has been completed, then the BSSC expects to turn its attention to that of seismic safety in existing buildings which, in my opinion, poses even a greater threat to life loss and property damage than does new construction.

The role of the Interagency Committee on Seismic Safety in Construction's subcommittees on existing buildings needs to be clearly focused. This project was inactive in fiscal year 1981 due to a lack of FEMA, and agency resources. To date, no resources have been identified for 1982.

In addition, I would respectfully urge that the role of the National Bureau of Standards be strengthened in carrying out the intent of the act. Within the Center for Building Technology of NBS, they maintain as activities, laboratory, field and analytical research on the performance of buildings. As the principle federal earthquake engineering research group, they maintain a highly technical staff and extensive laboratory research programs.

I suggest that FEMA be urged to make the funding available to the NBS in order for them to maintain the progress of the BSSC and the ICSSC. Moreover, I recommend the the NBS funding required for research and standard development related to seismic safety in new and existing buildings be adequately appropriated.

It is estimated that in the event of a major earthquake in California, that the number of lives lost will be between 3,000 and 23,000, depending on the time of the day of the occurrence. In addition, the losses in both real and personal property are estimated to be in the areas of 17-38 billion dollars.

If we compare the potential life and property losses to the levels of funding required for the BSSC and the NBS to continue on with their programs in an adequate, responsible manner, the BSSC and NBS funding requirements become minimal.

I have two final recommendations:

(1) I would recommend that a technical education/training program be developed (with funding responsibilities shared between the federal government and participating organizations) in order to conduct symposiums on the latest state-of-the-art in seismic safety. There is a real need for training of both state and local building code enforcements officials on this highly technical subject of seismic safety.

(2) That a delivery system amongst and between federal, state and local governments be developed that would speed up the application of research done at the federal level. There exists a definite time lag between the completed work and the application of same.

EARTHQUAKE HAZARDS ARE TOO GREAT TO IGNORE.

I will be pleased to answer any questions you may have, Mr. Chairman. Thank you.

Mr. WALGREN. I especially appreciate that and, in particular, the specificity with which you focused on underfunding. It is very helpful testimony to the committees.

Let me then turn to Dr. Charles Thiel. I think in fairness to the time we are going to try to further compress this into 5 minutes with a little flexibility to go beyond, because we do not want to leave things unsaid, but I do want to keep the pressure on if I can.

Dr. Thiel.

STATEMENT OF DR. CHARLES C. THIEL, WOODWARD-CLYDE CONSULTANTS

Mr. THIEL. Thank you, Mr. Chairman. Having started out with the understanding that I had 20 minutes, I may have a little difficulty getting there, but anyway it is a pleasure to have the opportunity to testify on the reauthorization of the National Earthquake Hazards Reduction Act, I might say at this time, unfettered in my new position in the private sector.

Over the years many witnesses have recounted to the Congress the nature of the threats posed by earthquakes. Suffice it to say that the threat is national in scope, both in terms of the hazards and distributed impacts and unprecedented in their potential destruction. With each passing day, as Senator Schmitt has suggested, those risks are increasing and becoming more clear.

It is fitting, in my view, that after 5 years the Congress not only considered those administration-proposed programs before it for reauthorization but also examined how conditions and knowledge have changed over the last 5 years in ways that may affect program performance and achievement of goals.

In this context I will address four basic questions. First, is there a continuing Federal role? Second, how well have we performed? Third, what do we know that we are not applying? And, fourth, what should the Federal Government do to do a better job?

While preparing for this hearing and observing the proposed witness list, I became concerned that there were many more perspectives to be heard than time would allow to be presented. I contacted a number of organizations and sought their counsel on how I should form my testimony. My testimony does indeed draw heavily upon these statements.

These included the Earthquake Engineering Research Institute, the Applied Technology Council, the Structural Engineers Association of California, the California Seismic Safety Commission, the California Governor's Emergency Task Force on Earthquake Preparedness, and the California Emergency Council.

In my view, there is a need for a continuing Federal role. The impacts of the potential earthquake, such as the $17 billion event in terms of damage that has been postulated or suggested for planning purposes, could occur in southern California, would have associated with it probably on the order of $30 billion in total impacts.

It is my estimate that approximately $17 billion of this, or about the same amount as there is physical damage, would accrue to the Federal Government in terms of direct and indirect costs, ranging over a variety of issues in terms of food stamps, casualty deductions on taxes, the disruption of procurement processes and the resulting increases in cost as well as potentially affect the present capability of the country's defense preparedness.

I will not go into the other issues that I think indicate why there should be a continued role in the interest of time, but I would like to say that with the massive implications for the public's health and safety there seems little choice other than to continue a Federal presence in this program.

Going to the second question, how well have we performed, since the San Fernando earthquake we have made tremendous strides in our understanding of earthquake hazards and in our practice of reducing hazards. We have gone from a State in the early 1970's where we thought the issues were principally seismology, geology, and structural engineering and we were fairly confined to the design and construction of fairly large facilities from a rather narrow disciplinary basis.

Suffice it to say that we now find ourselves in a position where we recognize the problems to be much more difficult or much more pervasive than we had suspected or possibly were willing to admit to ourselves.

During the past 2 years, particularly, there has been an extensive consolidation and redirection of individual agency programs combined with budget constraints. These have acted to cause program changes that are not in harmony with the overall multiagency national effort. A few notable events in the last year and a half are: at NSF the merger of the highly problem-focused engineering and societal response programs into the Division of Civil and Environmental Engineering's basic research programs and the resulting focus on more traditional modes of basic research support.

At NBS, the budget constraints on the Center for Building Technology—indeed, no direct appropriations—leading to a reliance on an already constrained minimal FEMA budget for support.

At USGS, the initially-proposed dropping by the Department of the Interior of earthquake prediction from the 1982 program outside the context of its importance to the overall national program and interest.

At FEMA, the emphasis of pressing needs to improve a flagging civil defense program and resulting reduction in planned earthquake preparedness and mitigation initiatives.

At other Federal agencies that have supporting roles in the national program but without direct budget appropriations, the redirection of staff efforts and commitments resulting in non- or nominal participation; and, last of all, within the Congress, the consistent actions of the Appropriations Subcommittees to play one agency's budget against another without recognizing the whole program.

When budgets were rising and agency managements were visible, it was rather easy for agencies to act like statesmen, but I leave it to your devices now to suggest whether they are now.

There is a great deal that we know that we are not applying. The breadth of opportunities to produce earthquake hazards mitigation through preparedness, through response are large compared to our actions and our knowledge is substantial.

Let me go on to comment on the things that I think we ought to do so that the Federal Government can do a better job. First, I support the reauthorization of the act and endorse the original objectives in 1977, many of which have yet to have substantial effort applied to them.

When we had completed the formation of the National Earthquake Hazards Reduction Program under an OSTP initiative with the support of an external working group as well as an internal working group, we thought it best to assign that program's coordination and management to FEMA, which was a newly proposed agency at the time, flowing out of a presidential reorganization project.

When FEMA was formed, in a sense the other programs had an easier time since they were ongoing staffed and budgeted efforts. The earthquake program, however, had no historical staff or program and still it has little. We have learned a great deal in the interim about how to provide for the public's safety and found that many of the constraints at work in the private sector and in State and local government and within the public are indeed not constraints, but they are acting to protect themselves.

I believe that it is now timely for us to reassess where we have been, what we have learned, what we can achieve, how we can organize and manage our resources best to achieve these goals. I recommend that the Congress direct the administration or, preferably, to establish its own independent effort independent of the administration to conduct an intensive review under independent leadership of comprehensive external advice, to report anew on how the national earthquake hazards reduction program should be structured, staffed and managed to achieve the still-relevant objectives written by Congress into law in 1977.

I would urge that this be conducted in the near term and that we not wait for yet another budget cycle which may prevent action for at least 2 or possibly 3 years.

In the interim, I recommend that, first, the act be reauthorized. Second, with the various supporting agencies that were referenced in the National Earthquake Hazards Reduction Act who are members of the Interagency Committee on Seismic Safety in Construction be requested to report to the members of Congress in detail on their activities in support of the national program and the extent of their staff and budget support for fiscal years 1982 and 1983.

Third, I recommend that the agencies authorized under this program be directed to intensify, and intensify substantially, their efforts in project-oriented efforts to: First, formulate and test policies and practices to improve seismic safety, such as those of the Building Seismic Safety Council; second, to reduce that which we know and which good professional practice indicate into a series of manuals of practice, guidelines and the like, that can be a basis for improved earthquake mitigation practice in the private sector and by the public; third, to disseminate information, data, and knowledge developed under the program to those who can utilize it at a substantially greater effort than is currently underway.

Fourth, to participate in State and local preparedness efforts and professional organization standards processes that are ongoing under other initiatives.

And, fifth, as a major recommendation, I would suggest that the Congress should direct Federal agencies to levels of effort in research, mitigation, preparedness, and response that are appropriate to the threat by legislative direction and budget decisions.

The implementation of these steps for the short term, and the systematic reexamination of the program and its reformulation in the long term will, I believe, lead to the strengthening of the national effort and ultimately to the savings of untold thousands of lives and billions of dollars in property in the coming decades as those certain damaging earthquakes will occur.

Thank you.

[The statement follows:]

STATEMENT OF CHARLES C. THIEL, JR.

Mr. Chairman, members of the committee, it is a pleasure to have, once again, the opportunity to appear before you as you consider the reauthorization of the National Earthquake Hazards Reduction Act of 1977. My views are as one in the private sector who is tempered by long association with the Federal Program.

Over the years, many witnesses have recounted to the Congress the nature of the threat posed by earthquakes. I'll not repeat their presentation. Suffice it to say that the threat is national in scope both in terms of the hazard and the distributed impacts of a great event, no matter where it occurs, as it works its way through the economy. And, with each passing day, the risk increases.

It is fitting that after five years, the Congress not only consider the administration's proposed programs before it for authorization, but also examine how conditions and knowledge have changed over the past five years in ways that may affect program performance achievement of goals. In this context, I will treat several successive questions:

(1) Is there a continuing Federal role?
(2) How well have we performed?
(3) What do we know that we are not applying?
(4) What should the Federal government do to do a better job?

While preparing for this hearing and observing the proposed witness list, I became concerned that there were many more perspectives to be heard than time would allow to be presented. I contacted a number of organizations seeking their counsel on issues that should be brought to the Congress' attention. I have appended to my testimony (Attachment I) those received from the Earthquake Engineering Research Institute, the Applied Technology Council, the Structural Engineers Association of California, The California Seismic Safety Commission, the Governor's Emergency Task Force on Earthquake Preparedness, (California) and the California Emergency Council. I have drawn heavily on these statements and commend them for your serious consideration.

IS THERE A CONTINUING FEDERAL ROLE?

Some have argued that since a great earthquake will affect a relatively small area of the country, the national government has a relatively minor role, whether in terms of mitigation, preparedness, or response. While the direct damage may be geographically limited to a few tens of thousands of square miles, the economic effects will be much more widespread. The National Security Council study of two years ago estimate that if the Southern San Andreas event were to occur, we could expect about $17 billion in direct damage and over $30 billion in total impact. It is my estimate that the Federal costs for such an event will be about the same as the physical damage, $17 billion, albeit over a few years, with equal contributions to the Federal cost from direct and indirect costs. This Federal involvement will be forced by:

The impacts on defense and national security installations and the resulting possible effects on our defense posture;

The interruption of Federal procurement of goods and services;

The damage or destruction of Federal facilities and the loss of Federal workers due to injury, death, or other alternative compelling needs for their labor;

The direct costs of increased unemployment compensation, food stamps: the indirect cost of casualty losses on income taxes, Federally held or guaranteed mortgages on damaged or destroyed property (VA, FHA, FMHA holdings);

The disruption of Federally performed functions in communications (e.g., Federal Aviation Administration), financial operations (e.g., Federal Reserve Bank clearing), and income maintenance programs (e.g., Social Security);

The provision of assistance to the affected communities for life and property saving functions through the use of Federal resources (e.g., bulldozers), personnel, and technical expertise; and

Financial backing for long-range recovery activities.

Thus, the Federal government must be prepared to know how it will respond to protect Federal property, ensure continuing functioning of Federal services, and provide assistance to stricken communities and individuals.

Another related issue that can be addressed most effectively by the Federal government is sponsoring of research and development on mitigation, particularly building practices. The Federal costs can be effectively reduced by limiting the vulnerability of structures to damage. The building community is one of the most regulated industries in the United States. The principal form of regulation is through the local building officials charge to enforce locally adopted building codes. The public has delegated to these officials responsibility to assure a safe and adaquately built environment. The nature of this system is such that there is little economic incentive to improve codes on the part of materials suppliers or designers. The autonomous nature of thousands of independent jurisdictions is such that there is no critical mass for the support of research or development at less than the national level. If advancement is to be accomplished through research and innovation, the Federal government is the only viable support source.

Thus, with such massive implications for the public's health and safety, there seems little choice other than to continue a Federal presence. The level and extent of this involvement is open to discussion, but its presence, in my view is absolutely necessary.

HOW WELL HAVE WE PERFORMED?

Since the San Fernando earthquake, we have made immense strides in our understanding of earthquake hazards and in our practice to reduce earthquake hazards. The Congress and this and previous administrations can be justifiably proud of the leadership they have taken in making these advancements.

In the early 1970's, the principal focus of the National Program was research. The issues were seismology, geology, and structural engineering and were fairly confined to large buildings, dams, nuclear power plants and other monumental structures. The disciplinary mix was narrow and we all knew each other. Now, the issues are seen as being successively more complex and less amenable to the approaches of the past. We now see seismic safety through the eyes of engineers, architects, planners, social scientists, public officials, lawyers, disaster response personnel—and we see problems that we hadn't focused on before: the fragility of lifelines, the destruction of industrial production capability, the reduction in defense readiness, economic disruption, relief and rehabilitation, and a miriad of other things that were there before but were masked by our assignment of pre-eminence to the problems of providing safe buildings.

The Newmark-Stever report of 1976 started the awakening, and the National Earthquake Hazards Reduction Act, especially Section 5(b(2) requirement for an implementation plan, subsequently submitted by the President on June 22, 1978, cemented it. And, what has happened in the meantime within the context of directly funded activity of the program in 1982?

Fiscal year 1982

	Millions
National Science Foundation:	
Earthquake hazards mitigation	$18.2
Seismology and deep earth structure	5.3
Geological Survey	32.7
National Bureau of Standards	.4
Federal Emergency Management Agency	.9
Total	57.5

These figures are basically unchanged from 1978. Notwithstanding the impacts of inflation and the fact that research programs could make productive use of increased funds, I believe that the overall Federal commitment in total resources is adequate and need not be increased. The manner in which these funds are allocated is another matter that I will address subsequently.

During the past two years, extensive consolidation and redirection of individual agency programs combined with budget constraints, have caused agency program changes that are not in harmony with the overall multi-agency national effort. A few notable events are:

> At NSF, the merger of the highly problem-focused engineering and societal response programs into the Division of Civil and Environmental Engineering's basic research program and the resulting focus on more traditional modes of NSF research support;
>
> At FEMA, the absorption of NEHRP coordination functions into the State and Local Programs and the resulting emphasis on preparedness;
>
> At NBS, the budget constraints on the Center for Building Technology leading to a reliance upon an already constrained FEMA budget for support;
>
> At USGS, the initially proposed dropping of earthquake prediction from the fiscal year 1982 program outside the context of its importance to the overall national program;
>
> At FEMA, the emphasis of pressing needs to improve a flagging Civil Defense program and resulting reduction in planned earthquake preparedness and mitigation initiatives;
>
> At other Federal agencies that have supporting roles in the NEHRP but without direct budget allocations, the redirection of staff efforts and commitments resulting in non-or nominal participation;
>
> In the Congress, the consistent actions of Appropriations subcommittees to play one agency's budget against another without recognizing the whole program.

When budgets were rising and agency management was visibly (and vocally) committed, good will was rampant and it was easy for statesmanship to prevail; but now, when budgets are effectively declining and agency stress is great . . . well, I leave it to your imagination. It used to be that NSF would make aggressive grants to foster utilization and dissemination of information to the public; but now they tend to defer to FEMA, which has nó funds to speak of; thus, the net effect is less utilization action—yet neither agency has acted outside its organic charter.

WHAT DO WE KNOW THAT WE ARE NOT APPLYING?

There has been a change in our expectations during the past five years. In 1977, we were optimistic about our ability to predict earthquakes within a few years. Our progress has not been nearly as rapid as we desired because the problem has proved to be a lot tougher than we thought. Yet, while there is divergence of opinion within the scientific community, the outlook for short term prediction is guardedly optimistic. The improvement in long-term prediction, on the other hand, has progressed substantially more rapidly than expected. Again 1977, there was a general feeling that improvement in public preparedness for response to earthquake occurrences would come with great difficulty. Yet, now we see communities and industries in California making major commitments to prepare themselves. We previously thought that the materials industries would erect major obstacles to improving codes and regulations, but now find that they are leading productive efforts for their improvement as evidenced by the Building Seismic Safety Council.

In a sense, the research efforts of the past five years have been so overwhelmingly successful that we now know proportionally more than we are applying, compared to five years ago. Past efforts have focused on the development of new knowledge—a process far from complete. However, there is sufficient knowledge and experience now to initiate a larger portion of project-oriented activities designed to develop, test, synthesize and demonstrate the efficiency and cost effectiveness of earthquake hazards mitigation strategies and to provide incentives for and models of improved seismic safety. Further, with what we now know, we could productively initiate tailored information and educational efforts directed at the public and professional communities to improve their seismic safety actions.

WHAT SHOULD THE FEDERAL GOVERNMENT DO TO DO A BETTER JOB?

When confronted with the provocative question of how the Federal government should organize and manage itself to achieve the purpose set out in PL95-124 ". . . To reduce the risks of life and property from future earthquakes in the United States . . ." both the Executive and Legislative branches responded by deferring decisions until an implementation plan could be prepared, evaluated and submitted to Congress for approval rather than proceeding with a prescriptive set of actions. After an extremely intensive effort under the direction of OSTP, counsel from an advisory committee chaired by Karl Steinbrugge, and support of a Federal Working Group, the National Earthquake Hazards Reduction Program was developed. This was a novel undertaking for which I am aware of no precedent. During the program's development, a proposal was made by the President's Reorganization project to bring together emergency management functions under a proposed Federal Emergency Management Agency (FEMA). It seemed reasonable then to assign overall coordination of the NEHRP to FEMA as well as responsibility for preparedness and several other operational functions. Thus, both FEMA and the NEHRP were born at the same time both undertaking efforts for which there were no effective precedents. The other FEMA programs, in a sense, had an easier time since they were ongoing, staffed efforts; the NEHRP, however, had no historical staff or program.

We have learned a great deal about how to improve the public's safety since those heady days of 1977 when a few of us invented the NEHRP. one of the things that we best learned is that there are many more ways to affect the public's safety and means to cause their action than we then thought realistic. To give an example of the breadth of approaches that we might follow. I have appended "A Framework for Earthquake Hazards Reduction Policy Development", (Attachment II) prepared by myself and Ugo Morelli as part of a recent paper entitled: "An Approach to Seismic Safety For the Central United States".

As I have suggested earlier, with five years' experience, it is no longer clear to me that the Newmark report on research (1976), the Steinbrugge report on implementation issues (1978), or the NEHRP (1978) any longer represent our current thinking on how to apportion, direct and manage a program to achieve improved national seismic safety. It is not clear that, when budgets are constrained and agencies are free to take independent actions overall program direction and momentum can be maintained without a single budget managed by an agency with overall program responsibility. Nor is it clear that the past reliance upon voluntary participation, supplemented by part-time Federal staff support, is the means to reassess this program.

I believe that it is timely to reassess where we have been, what we have learned, what we can achieve, and how we can organize and manage our resources for achievement. I recommend that the Congress direct the administration (or preferably to establish its own effort independent of the administration) to conduct an intensive review under independent leadership and with comprehensive external advice representing a balanced view of all interests, and report anew on how the NEHRP should be structured, staffed, and managed to achieve the still relevant objectives written by Congress into law in 1977. Such an effort is required, in my judgment, if we are to continue to have confidence that the public's funds are being used to maximum advantage and that the public's safety is being increased with economy and efficiency. Such a study can be completed in time to have its recommendations before the Congress by next year's hearings, if we do not wait for the completion of this budget cycle but begin now. I do not believe that such a study should pre-suppose increasing budgets. Indeed, I would constrain it to established resources (adjusted for inflation), except for those efforts that may, from time to time, require substantial implementation costs over brief periods. Further, I would require the study to first develop a comprehensive, goals oriented program prior to formulating options for its effective management.

In the interim, I recommend that:

(1) The National Earthquake Hazards Reduction Act be reauthorized at overall levels consistent with the Administration's request;

(2) The various supporting agencies who were referenced in the NEHRP and who are members of the Interagency Committee on Seismic Safety in Construction be requested to report to the Congress in detail on their activities in support of the NEHRP and the extent of their staff and budget support for fiscal years 1982 and 1983.

(3) The agencies authorized under this program be directed to intensify their efforts in project-oriented efforts to:

formulate and test policies and practices to improve seismic safety. These policies and practices can be applied by diverse professions and organizations in varying geographic areas to accommodate the twin demands of economy and safety;

reduce that which we know and that which good professional practice indicate into a series of manuals of practice, guidelines, and the like, that can be a basis for improved earthquake mitigation practice;

disseminate information, data, and knowledge developed under the program to those who can utilize it, and;

participate in state and local preparedness efforts and professional organization standards processes.

(4) Direct Federal agencies to levels of effort in research, mitigation, preparedness and response by legislative direction and budget decision.

The implementation of these steps for the short term, and the systematic re-examination of the program and its reformulation in the longer term, will, I believe, lead to the strengthening of the national effort and, ultimately to the savings of untold life and property in the coming decades as damaging earthquakes occur throughout the country.

ATTACHMENT I

STRUCTURAL ENGINEERS ASSOCIATION OF CALIFORNIA,
San Francisco, Calif., February 18, 1982.

Dr. CHARLES C. THIEL, Jr.,
Woodward-Clyde Consultants,
San Francisco, Calif.

DEAR DR. THIEL: It is our understanding that you will be testifying before Congress sometime in March 1982, to assist in the establishment of an effective program for earthquake hazards mitigation. The Structural Engineers Association of California has always been deeply involved in this area and would appreciate expressing our views to Congress through you, and to provide any support required within our means to the advancement of earthquake hazards mitigation.

Vitrually none of the United States is totally exempt from earthquake activity. The east, mid-west, and in particular, the western states are subject to the occurrence of an extreme seismic event. In the event of an earthquake, the loss of life and property would be enormous in the densely populated areas. These losses could be greatly reduced if an effective earthquake hazards mitigation improved program were established.

The Structural Engineers Association of California has spent thousands of voluntary hours addressing the problems associated with earthquake engineering of structures and will spend many more. Our efforts are directed towards improving the seismic design criteria for buildings in order to minimize the life and property loss. As a voluntary group, our Association depends a great deal upon research that has been or is being performed. As the knowledge of the effects of seismicity continues to expand, so does the need for more in depth research to assimilate this knowledge for the benefit of the citizenry of this country. All monies invested now for research in the area of earthquake engineering would be an extremely low price to pay for the end results of saving lives and property when disaster does occur—as it most assuredly will.

May we take this opportunity to thank you for expressing our views to the Congress.

Respectfully yours,

GERALD H. HAINES,
President, Structural Engineers Association of California.

APPLIED TECHNOLOGY COUNCIL,
Berkeley, Calif., February 24, 1982.

Dr. CHARLES C. THIEL, Jr.,
Woodward-Clyde Consultants,
San Francisco, Calif.

DEAR DR. THIEL: You will be testifying before Congress in March relative to steps necessary to accomplish effective earthquake hazard mitigation, including funding of research for the many unanswered questions in the area of earthquake engineering. Applied Technology Council requests an opportunity to express to Congress through you, by this letter, a brief statement of its concerns and philosophy regarding support required to maintain and improve the country's earthquake hazard mitigation effort.

Damaging earthquakes have occurred and will continue to occur in many regions of the United States, including California, Alaska, Utah, the Pacific Northwest, the New Madrid area (Missouri), and parts of the Northeast. Earthquakes of moderate magnitude that occur in populated regions can cause extensive damage and numerous casualties, and those with magnitudes greater than 7 can be many times more devastating. The most costly recent earthquake in the United States, in terms of casualties (58 killed and 125 injured) and structures damaged ($500 million), was the magnitude-6.4 1971 San Fernando, California, earthquake. The effects of that earthquake, however, pale in comparison to the estimates of damage that would result should there be a large-magnitude (greater than 7) earthquake near one of the large metropolitan areas of California (e.g., $44 billion in damage estimated for a magnitude 7.4 on the Hayward fault near San Francisco ("An assessment of the consequences and preparations for a catastrophic California earthquake: findings and actions taken," FEMA, 1981).

The public expects, and rightly so, that reasonable efforts be undertaken to mitigate the hazardous effects of earthquakes. To achieve this mitigation in a cost-effective manner, it is essential that there be adequate funding both for earthquake research and for implementation of research findings. Earthquake research is required to better understand the nature of earthquakes, to develop an earthquake prediction capability, and most importantly, to identify ways to minimize the hazardous effects of earthquakes, particularly damages to buildings and other structures. As significant research findings become available, it is essential that these be made available as quickly as possible to the appropriate practicing professions, including design engineers and regulatory authorities. Rapid and effective technology transfer between the research and practicing communities, in combination with a strong research program, is crucial if this country is to reduce substantially the hazardous effects of earthquakes.

The importance of technology transfer is emphatically underscored by the structural failure of modern engineered buildings during earthquake-induced ground shaking. A well-known recent example of such a failure was the 8-year-old $1.87 million Imperial County Services Building located in El Centro, California. Although it was designed to resist earthquakes, this building was so severely damaged by the October 1979 Imperial Valley, California, earthquake that it had to be demolished. Such building failures clearly and dramatically demonstrate the need to constantly upgrade seismic codes as more is learned about ground shaking and structural response.

Applied Technology Council applauds the actions taken by Congress in recent years to minimize the effects of earthquakes and asks that Congress authorize the continuation of the earthquake hazards reduction program. One need only compare the catastrophic loss to life and property frequently experienced elsewhere in the world as a result of even low-intensity earthquakes with the relatively minor loss, if any, sustained in this country where ongoing private sector-government partnership programs geared to life safety now exist. The dollars spent today on earthquake research and on the implementation of research findings will be repaid many times over in savings of lives and property during future earthquakes.

Sincerely,

SAMUEL SCHULTZ, *President.*

EARTHQUAKE ENGINEERING RESEARCH INSTITUTE

A RESOLUTION BY THE EERI BOARD OF DIRECTORS TO THE CONGRESS OF THE UNITED STATES CONCERNING REAUTHORIZATION OF THE EARTHQUAKE HAZARDS REDUCTION ACT

Reauthorization of the Earthquake Hazards Reduction Act is essential to reduce future life-loss and property-loss from earthquakes in the United States. Although earthquakes are commonly regarded as a westcoast problem, recent small earthquakes in the East have reminded us that damaging earthquakes are not a California phenomenon. In fact, earthquake experts have recently suggested that major earthquakes in the United States may occur in the near term in the Midwest or East as well as in the West. A major earthquake in an urban center could immobilize large segments of the government and economy of the nation, costing thousands of lives and weakening our ability to respond to external threats as well. Even moderate earthquakes are expensive and disruptive.

While engineering practices have improved substantially in recent years, two modern high-rise buildings have failed in recent moderate U.S. earthquakes. The Olive View Hospital, a $25 million structure which was dedicated only months before the February 9, 1971 San Fernando, California earthquake was damaged beyond repair. In 1979, the Imperial County Services building in El Centro, California, built only eight years earlier, was so severely damaged that officials decided to demolish rather than repair the building. At the same time in each event other structures showed little damage. These two earthquakes measured 6.4 and 6.6 respectively on the Richter magnitude scale. By contrast, the famous 1906 earthquake in San Francisco is estimated to have been of Richter magnitude of 8.3.

Much progress toward mitigating the earthquake problem in the United States has been realized in recent years, and the previous funding authorization of the Earthquake Hazards Reduction Act (Public Law 95-124) has contributed significantly to this progress. Important advances can be cited for each of the five principal disciplines involved in the earthquake problem, namely: geosciences, engineering, architecture, urban planning, and social sciences. Yet, in spite of the advances that have been made, it is still impossible to secure a majority opinion regarding how to preclude failures, like those cited above, from occuring in future earthquakes.

The lack of certitude that prevails in seismic design and construction today results from yet undiscovered knowledge among researchers as well as a lack of awareness of knowledge discovered but not disseminated among all practicing professionls. Work vital to realizing additional needed earthquake hazards reduction can be broadly classified as follows:

Fundamental research
Applied research
Technology transfer involving evaluating and translating research and experiences to practice
Information dissemination

One area of research, among many, bears highlighting. An extremely important activity for ensuring earthquake-resistant construction of buildings and other structures is the acquisition of test data to quantitatively predict performance during future earthquakes. Basic theoretical concepts of how to design earthquake-resistant structures is currently well established. A significant amount of experimental testing, usually at small-scale on single components, aimed at quantitatively relating earthquake parameters with structure response and performance parameters has already been conducted. While the testing conducted has been of significant benefit in advancing the science of earthquake engineering, the situation today is that sufficient data has not yet been amassed to quantitatively predict the performance of typical building structures for future earthquakes. This current limitation in the science and practice of earthquake engineering can be overcome only by securing additional test data. Tests of full-scale structures, either from laboratory experimentation or from earthquake observations are particularly needed. Full-scale testing is costly, and requires commitment of many investigators, but it is essential for verifying the theoretical bases for earthquake-resistant design which has been so well developed in recent years.

As the national technical society concerned with earthquake hazard reduction—with a membership of over 1,000 engineers, geologists, seismologists, architects, planners and social scientists—EERI urges that Congress reauthorize the Earthquake Hazards Reduction Act in order to realize the scientific advances needed to ameliorate earthquake impacts. Important consideration in the reauthorization should be:

(1) The program be national in scope, to address the varying earthquake conditions and building construction practices throughout the United States,

(2) The program be administered by a governmental agency or earthquake advisory board staffed with geoscientists (including those involved in both earthquake prediction and geologic hazards evaluations), engineers, architects, urban planners, emergency managers, social scientists, public officials and businessmen in order to provide the necessary coordination and administration of all aspects of the program,

(3) The program be authorized for five years to ensure the continuity needed for planning and cost effectiveness, and

(4) Program support should be increased in an orderly way to $250 million per year within five years to assure that a comprehensive goal-oriented program of research and implementation is underway. The current effort at the $60 million level represents a limited approach to the problem and is not responsive to the potential benefit, the major threat, nor our capacity.

At the direction of the Board of Directors February 27, 1982.

ROGER SCHOLL, *Technical Director.*

STATE OF CALIFORNIA—SEISMIC SAFETY COMMISSION

Reply to: Stanley Scott, Assistant Director, Institute of Governmental Studies, University of California, Berkeley, Berkeley, Calif.

MARCH 9, 1982.

Hon. Doug Walgren, U.S. House of Representatives, Chairman, Subcommittee on Science, Research and Technology.

Hon. Doug Walgren, U.S. House of Representatives, Chairman, Subcommittee on Science, Research and Technology.

From: Stanley Scott, Chairman.

Re: reauthorization of the Earthquake Hazards Reduction Act.

I write to express the hope that you will support reauthorization of the Earthquake Hazards Reduction Act, legislation originated by Senator Alan Cranston and Congressman George Brown.

This statute represents a very significant federal commitment to earthquake safety, whose objectives have stood the test of time. Moreover new information now provides even more persuasive justification for the statute than was available when it was originally enacted.

We in California readily acknowledge our perhaps dubious but well-established distinction as the nation's region with the highest seismic activity. But we also note growing evidence and expert opinion that most of the country's populous areas are also subject to some degree of seismicity, which clearly seems to call for thoughtful, long-term further investigation and evaluation.

Because California's hazard is greater, it is appropriate that this state took the lead in seismic policy and earthquake-hazard reduction. These objectives have been pursued diligently, particularly after special efforts were initiated under the administrations of both former Republican Governor Ronald Reagan and present Democratic Governor Edmund G. (Jerry) Brown, Jr. With the topic receiving such broad, bipartisan attention, we have made encouraging progress on earthquake policy, although we must also candidly admit that we still have a long way to go before fully resolving deepseated and pervasive problems.

In any event, we welcome the continued and even more active participation and involvement of the federal government as a major partner in the process. In turn, we express the hope that California can continue in its leadership role, and within the limits of its resources can assist the federal government wherever possible to further the national interest in improved seismic safety.

To that end I repeat the hope for prompt reauthorization of the Earthquake Hazards Reduction Act. It is an appropriate vehicle to help focus the federal contribution to greater earthquake safety. Especially needed is problem-focused research—both basic and applied—on earthquake preparedness, hazard-mitigation, response, and recovery. Support is also needed for earthquake-related research in the physical sciences (especially the earth sciences), and engineering, as well as the social sciences. We also believe that reauthorization of the Earthquake Hazards Reduction Act will contribute significantly.

STATE OF CALIFORNIA

GOVERNOR'S EMERGENCY TASK FORCE ON EARTHQUAKE PREPAREDNESS

Whereas the State of California is at major risk to the occurrence of a catastrophic earthquake which will have major nation impacts

Whereas the Governor of the State of California has appointed the Governor's Emergency Task Force on Earthquake Preparedness to develop improved state earthquake preparedness and foster improved public preparedness;

Whereas the Governor's Emergency Task Force on Earthquake Preparedness represents a broad cross section of concerned citizens, local officials, state officials, and professional groups; and

Whereas the Congress is now considering reauthorization of the Earthquake Hazards Reduction Act, Public Law 95-124: Therefore, be it

Resolved, That the Federal government is to be commended for its initiative in supporting a broad program of research that has lead to a fund of knowledge which has the potential for reducing life and property loss and for its support in improving earthquake preparedness;

There is a pressing need for enhanced Federal participation of qualified personnel, as an equal partner in state and local preparedness efforts;

More effort needs to be applied by Federal agencies and contractors to translate into specific recommendation on policy, practice and programs through experience and research knowledge developed under Federal support;

Legislative direction and budget decisions should direct Federal agencies to a more balanced effort of research, mitigation, preparedness and response.

For the Task Force:

WILLIAM W. WHITSON, *Chairman.*

RESOLUTION

CALIFORNIA'S EMERGENCY COUNCIL

Whereas the State of California is a major risk to the occurrence of a catastrophic earthquake which will have major national impact; and

Whereas the California Emergency Council is established by the California Emergency Services Act to advise the Governor with reference to emergencies; and

Whereas the California Emergency Council represents the Governor, Lieutenant Governor, Attorney General, Senate, Assembly, County Government, City government, Fire Services, Law Enforcement, and the American Red Cross; and

Whereas the congress is now considering reauthorization of the Earthquake Hazards Reduction Act, Public Law 95-124: therefore, be it

Resolved, That the Federal government is to be commended for developing a wide spectrum of research to further enhance the capabilities of the nation to reduce life and property loss in event of a major or catastrophic earthquake;

There is a continuing need for intensified participation of qualified personnel at the Federal level, in state and local preparedness efforts;

Federal agencies and contractors need to improve and expand their efforts to translate research and scientific knowledge in public policy, practice and programs;

Federal agencies should be led by legislative and budget decisions to appropriate levels of effort in research, mitigation, preparedness and response.

ATTACHMENT II

TAKEN FROM "AN APPROACH TO SEISMIC SAFETY FOR THE CENTRAL UNITED STATES" BY C. C. THIEL AND U. MORELLI IN PROCEEDINGS, A WORKSHOP ON "PREPARING FOR AND RESPONDING TO A DAMAGING EARTHQUAKE IN THE EASTERN UNITED STATES" USGS, 1982

A FRAMEWORK FOR EARTHQUAKE HAZARDS REDUCTION POLICY DEVELOPMENT

While "mitigation" is often taken to mean increasing structural strength of structures, its full and more useful connotations are much broader. Mitigation is a management strategy to balance current actions and expenditures with potential losses from future hazard occurrences. It is useful to put mitigation activities into perspective with the other actions which can be taken to control the consequences of hazard occurrences. Mitigation is but one aspect of emergency management, usually characterized as an element in a progression that includes actions before, during and after the event. Mitigation activities are those that eliminate or reduce the probability of occurrence of a hazard event, or those that reduce the impacts of a hazard occurrence. Preparedness activities on the other hand are necessary to the extent that mitigation measures have not, or cannot, prevent disasters. In the preparedness phase, governments, organizations and individuals develop, test and maintain plans to save lives and minimize disaster danger. They also seek to enhance disaster operations during the emergency. Response activities follow an emergency or disaster. Generally, they are designed to provide emergency assistance for casualties while reducing the probability of secondary damage. Recovery activities continue until all aspects of community life return to acceptable, normal, or better levels. Short-term recovery activities return vital life support systems to minimum operating standards; long-term activities may continue for a number of years until the acceptable levels are achieved.

Mitigation may be pursued through a variety of approaches, taken alone or in combination. Unfortunately, there is a prevalent tendency to select one principal approach and not rely on a combined, often more economical, strategy. One taxonomy divides mitigation approaches into seven categories:

(1) Approaches which involve measures to minimize the probability of hazard occurrence (abatement) and/or to protect areas and building sites from the hazard (area protection). Actions which are intended to minimize the runoff of heavy rain waters are illustrative of the former, while the construction of dams and levees are illustrative of the latter.

(2) Approaches which focus on the strengthening of structures exposed to hazards or which focus on site-level systems for protecting buildings from such hazards. The use of shear panels to protect frame buildings or the reinforcement of masonry structures from earthquake vibrations are illustrative of the former.

(3) Approaches which give attention to site-development schemes for protecting structures from hazards. Suggestive of this approach is use of more appropriate grading practices to protect against earthquake-induced landslides.

(4) Approaches which involve the identification of hazard-prone sites and the use of means to prevent or restrict their development and use, such as fault and landslide mapping, restrictive zoning, and recreational use.

(5) Loss recovery, relief, and community rehabilitation approaches. Illustrative are earthquake insurance and the low-interest loans authorized by the Federal Disaster Relief Act.

(6) Hazard warning and selective population evacuation systems, such as those which might be employed in response to warnings of earthquake aftershocks or identification of an earthquake-weakened dam.

(7) Approaches which provide policy makers with the information and decision-assisting tools which facilitate rationale and effective hazard management decision making.

While this taxonomy provides a useful framework for the public or private decision-makers, it does not in itself provide a means for identifying how to effect the mitigation approach or for selection among alternative means to achieve desired performance.

The situations to which many citizens are so casually prepared to refer to as "public problems" can be remarkably difficult for the public policy-maker to define and act upon. For example, situations, impacts, or set of effects which may be defined as a problem by one group may be regarded as a solution by another; one person's cost can be another person's benefit; and action which solves one problem besetting a given group may impose yet a different problem on the same group. It is the function of the policy-maker to resolve these dilemmas.

All policy problems may be said to be the product of four factors:

(1) human perceptions of empirical reality,
(2) human desires and expectations for the future
(3) values that justify and define the desired future, and
(4) the human perception of gaps between the desired future and the present.

Whenever a gap has been perceived to exist between a desired and a perceived state of affairs, and whenever that gap has been disvalued by the observer, then a problem may be said to be present. Thus, at some point, any attempt at identifying a public problem must reflect a comprehension of the distinguishable groups of individuals whose interests are involved in that problem.

When the policy-maker identifies candidate problems, then two other questions must be addressed:

(1) what priority should be given to the solution of each problem, or any component thereof?

(2) what types of policies may be employed to deal with each priority problem?

In general, poblems can be operational and their relative priorities can be determined by addressing four questions:

How many people or how much area are adversely affected?

How intensely are these people and these areas being affected?

Will the problem situation get better or worse if nothing is done?

Is the greatest gain to be be derived from dealing with existing exposures or from preventing future ones?

There are a number of types of policies that offer a range of potential approaches to decision makers:

(1) Those intended primarily to force loss-reducing activities by State and local jurisdictions of government (action-forcing policies);

(2) Those intended to stimulate citizen, group, and governmental interest in losses produced by natural hazards and to elicit voluntary State, local, and private action to reduce such losses (attention-focusing policies);

(3) Those intended primarily to assist personal, familial, neighborhood, community and State recovery from the damages sustained as a result of exposure to a natural hazard (disaster recovery policies);

(4) Those focused primarily on development of new knowledge concerning the subject and on the information and technology necessary to support the making and implementation of hazard mitigating policies (technology development policies);

(5) Those focused primarily on transfer of knowledge to consumers, governments and others and on the development of user capacity to make effective use of that knowledge (technology transfer policies);

(6) Those intended to regulate the decisions and behaviors of private parties and other governmental entities so as to bring about the reduction of losses associated with exposure to natural hazards (regulatory policies);

(7) Those intended to fix responsibilities, to specify the means to be employed, and otherwise to define the restrictions to be met by Federally-sponsored hazard mitigation policies and programs (system management policies);

(8) Those intended to assure that other policies in the set are compatible with system goals, effective, internally consistent with each other, and in consonance with other National policies (system optimization policies); and

(9) Those focused on the acquisition and allocation of resources necessary to sustain the activities described above (investment and cost allocation policies).

It is important as we formulate earthquake hazards reduction policies, practices, and programs that we recognize that each of these nine policy approaches can be applied in consistent and mutually supportive ways to achieve desired levels of performance with economy and efficiency.

One clear lesson from California experience is that there is a strong tendency to adopt single policy approaches, and take them out of context with the overriding objective of providing appropriate levels of public safety.

Mr. WALGREN. Thank you very much, Dr. Thiel.

Next I would like to turn to Supervisor McElwain. I understand various witnesses have planes to catch and know that the committees, understand that too.

Supervisor McElwain.

STATEMENT OF CAL McELWAIN, SUPERVISOR, SECOND DISTRICT, SAN BERNARDINO, CALIF.

Mr. McELWAIN. Yes, providing we move right along on schedule, that may work out just right, but if we continue as we have, we are going to have trouble with our planes.

For people who do not know my name, it is Cal McElwain. I am vice chairman of the county board of supervisors, San Bernardino County, Calif., and vice chairman of the policy board directing the southern California project that is a partnership between FEMA and the State of California.

This, as far as I know, is the first partnership in the Nation. We are proud to be first. We have been for many years and we plan to stay there.

I have with me Howard Littlefield, who is the agency administrator for the agency who handles all emergency services. I also serve on the Governor's Council for Earthquake Preparedness and am a member of the executive committee for the Supervisors Association which addresses this and other emergencies.

I was most gratified to be invited to testify here. It was not an easy task to rearrange my schedule. I should be in Sacramento right now with the California Supervisors Association working on some of the things that I plan to be talking about here today.

Earthquake preparedness is of grave concern to us in San Bernardino, as in general to the people of southern California. It is of concern to other people throughout the Nation, too where earthquakes are a threat and prevalent and increasing.

There have been a number of things already said which I will not repeat and waste time. I will go right to our project and that is the southern California project.

As part of this project, we are now preparing emergency plans to respond to a catastrophic earthquake along southern California's portion of the San Andreas fault. We are developing them into a very unique way, in that the plans call for response to a prediction of an earthquake as well as response to an actual earthquake, and plans are being developed in four parts.

The first is response to a "long-term" predicted earthquake. That is, one which is predicted to occur 1 to 2 years in the future. This will include long-term planning actions such as changing building codes, identifying hazardous facilities, developing response plans and the like.

The second is a response plan to a "short-term" prediction where the earthquake is predicted to occur in 1 to 7 days. In this instance, our plan will call for those kinds of actions which would disrupt our normal way of life, including such things as closing facilities, businesses, regulating traffic, protecting critical utilities, facilities, and the like.

Third, is the "immediate" response plan of the actions to be taken following the disaster and through the first 72 hours where individuals would be essentially on their own, helping one another.

The fourth part, "short-term" recovery, a continuation of the immediate response activities, will include restoring supplies of food, water, shelter, communications, power, transportation, and similar actions to be taken during the first month after the disaster.

There is a further stage being developed separately by other planners in California which deals with long-term recovery. This involves the financial community, insurance industry and other statewide and national agencies which would be affected by such a major catastrophe.

I should say that our emergency planning for earthquakes is being carried out in conjunction with other local emergency plans because actions required for this contingency are much the same as our emergency planning for fires, floods, riots, civil disturbance. It probably is more closely associated with our civil defense preparations in response to a nuclear threat, and not to be taken lightly. Emergency planning requires a holistic approach, or integrated preparedness for all emergencies.

In conjunction with the development of these plans, we are also involving cities within our county, private industry, schools, military installations, and adjacent counties. We have close working relationships with the State of Nevada, particularly working with Clark County, in coordination of emergency matters. During the recent hotel fire disaster in Las Vegas our county provided backup resources from law enforcement helicopter airlift and from our medical emergency teams. We were held on standby for emergency assistance to burn victims. We have a burn unit within our county.

As part of our emergency response efforts, we are also planning to develop a regional emergency operations and education center for the northern part of our Central Valley area to serve this region as a headquarters for both emergency operations and communications during disasters, and as a training center to educate government and industry representatives from the southern California area in all aspects of emergency preparedness.

A major objective of this regional center will also be to provide training and implementation of civil defense measures which should be of interest should that program be upgraded as has been considered recently at the Federal level.

We are extremely gratified by the support and assistance we have received from the military jurisdictions in our area. In past emergencies, we have had close coordination and support from the Barstow Marine Base, 29 Palms Marine Base, and George Air Force Base. Representatives of Norton Air Force Base are actively participating with us in the SCEPP project and have a representative on our task force.

One other aspect of our southern California earthquake preparedness project which is indeed encouraging is the high level of participation we are receiving from the private sector, our chamber of commerce, all over our county and in Los Angeles County. The news media is all working closely with us in developing these plans and are helping to dissemination information to the general public, businesses, and industry.

I have to say that the news media has been very helpful to us. They have taken a great interest and we appreciate that.

In support of both earthquake preparedness and civil defense programs, we are also developing a neighborhood watch program which is piggybacking on law enforcement crime prevention programs already started in the county and several of our cities.

We plan to use these neighborhood watch programs to disseminate information on emergency preparedness, to train individual citizens and to develop a capability at the neighborhood level of people caring for each other and sharing resources during disasters—and especially earthquakes.

In the event the national defense program is revitalized, it should be recognized that civil defense is best carried out when it is part of an ongoing, highly localized program of overall emergency preparedness. I would hope that the future funding of our scarce Federal preparedness dollars are appropriated in that way. Jurisdictions which are prepared for local emergencies can most easily cope with a national disaster.

I have attached some backup information to the prepared statement which may be of interest to you, including our February 1982 status report on the SCEPP earthquake project and a project overview describing plans for the regional operations center.[1]

In summary then, San Bernardino County is deeply involved and actively engaged in developing earthquake preparedness for our area, but the effect of such a disaster will extend far beyond the boundaries of our county and even our State. The response to such a disaster will require more aid than can be provided by local and State governments.

Our efforts in emergency preparedness are increasingly difficult to continue with our dwindling local resources. Part of this is due to the need for more extensive research and development of earthquake technology which can only be accomplished at the Federal level.

We hope that the scientific community will continue to receive funding to expand their research and technology so that at some point in the near future we have a valid prediction model to forewarn us of imminent disasters of this sort.

Finally, I would like to reiterate that emergency planning involves many different contingencies, of which earthquakes are only one. Future funding for emergency preparedness would be more effective if it addressed all levels of preparedness, including local emergencies, regional disasters such as a San Andreas fault earthquake and national emergencies such as a nuclear attack.

We would like to see a national emergency preparedness program which would assist local and State governments in developing comprehensive emergency response plans. I think this would be a more acceptable way of preparing the public for disaster and a practical transition to real civil preparedness than embarking on a new civil defense program.

As you noticed, our report goes far beyond the earthquake preparedness, but we are interested in all emergencies and planning to react to all emergencies on a regional level. If you will notice, in the back there is copy of our disaster center plan and a photograph of our prototype situation.

At this time I wish to thank the subcommittees and my own local Representative, Mr. Brown, for asking me to appear here. I am prepared for questions, provided we finish at the appropriate time.

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[1] The material referred to has been retained in the committee files.

[The statement follows:]

STATEMENT OF CAL McELWAIN, SUPERVISOR, SECOND DISTRICT, SAN BERNARDINO COUNTY, CALIF.

Testimony of supervisor Cal Mc Elwain on behalf of the County of San Bernardino, California, before the joint hearing of the House Sub-Committee on Science, Research and Technology of the Committee on Science and Technology and the Senate Sub-Committee on Science, Technology and Space of the Committee on Commerce, Science and Transportation on reauthorization of the Earthquake Hazards Reduction Act of 1977, March 11, 1982.

Mr. Chairman and representatives of the Joint House-Senate Sub-Committees:

My name is Cal Mc Elwain. I serve as vice chairman of the board of supervisors for San Bernardino County, California, and as the vice chairman of the policy board directing operations of the southern California Earthquake Preparedness Project which is jointly sponsored by the Federal Emergency Management Agency and the California State Office of Emergency Services.

I am also on the Governor's council for earthquake preparedness and am a member of the executive committee of the County Supervisors Association of California.

I was most gratified by the invitation to speak before you today on earthquake preparedness because this subject is of grave concern to us in San Bernardino as it is generally to the people of southern California. It is also a growing concern to other communities throughout the nation where earthquake threats are prevalent.

Recent advances in earthquake research and technology has offered opportunities for making predictions of impending earthquakes and has identified many specific areas in the country which are likely to experience devastating earthquakes in the future. Much of this is contained in the report recently released by the U.S. Geological Survey.

While we are somewhat behind the prediction technology developed in China, Japan and other earthquake-prone nations, our scientific community has nevertheless made tremendous strides in recent years in acquiring additional seismological data and in developing prediction models.

One of the earthquake zones most well publicized in terms of recent earthquake predictions is the San Andreas Fault in California which runs through a good part of the State from Baja, California, to north of San Francisco and includes some of the most heavily populated sections of southern California, Los Angeles and the San Francisco Bay Area.

Scientists have voiced increasing concern that the build up of pressure along this fault has increased during the past 125 years to a point where we can expect a major earthquake compared in magnitude to the 1906 San Francisco earthquake which measured 8.3 on the Richter scale.

The death and destruction from such an earthquake with today's habitation of this area would be absolutely mind-boggling and could result in the loss of thousands of lives and billions of dollars in property damage.

The Federal Emergency Management Agency in November 1980 issued an assessment of the consequences of such a catastrophic earthquake in California and noted that losses along the four major segments of this fault could result in a total loss of property of over 160 billion dollars, upwards of 55,000 deaths and over 200,000 hospitalized, should the quake run the entire length of the fault.

Such a disaster would have a devastating effect on the industrial resources of California, particularly the aerospace and electronics industries and would have significant impact upon our national economy and national preparedness.

While this sounds like gloom and doom, we are very much encouraged by the planning efforts now underway in our country and throughout the southern California area in conjunction with the southern California earthquake preparedness project referred to locally as the "SCEPP Project."

As part of this project, we are now preparing emergency plans to respond to a catastrophic earthquake along the southern portion of the San Andreas. We are developing them in a very unique way in that the plans call for response to a "prediction" of an earthquake as well as response to an actual earthquake. The plan is being developed in four parts:

The first is response to a "long-term predicted earthquake", that is, one which is predicted to occur one to two years in the future. This will include long-term planning actions such as changing building codes, identifying hazardous facilities, developing response plans and the like.

The second part is a response plan to a "short-term prediction" where the earthquake is predicted to occur in one to seven days. In this instance, our plans will call for those kinds of actions which would disrupt our normal way of life and could involve such things as closing facilities or businesses, regulating traffic, protecting critical utilities and facilities, and the like.

The third is the "immediate response plan" of actions to be taken immediately following the disaster and through the first 72 hours where individuals would be essentially on their own, helping each other.

The fourth part, "short-term recovery", is a continuation of the immediate response activities and will include restoring supply of food, water, shelter, communications, power and transportation, and similar actions to be taken during the first month after the disaster.

There is a further stage being developed separately by other planners in California which deals with long-term recovery. This involves the financial community, Insurance industry and other state-wide and national agencies which would be affected by such a major catastrophe.

I should say now that our emergency planning for earthquakes is being carried out in conjunction with other local emergency plans because the actions required for this contingency are much the same as our emergency planning for fires, floods, riot and civil disturbance, and probably is more closely associated with our civil defense preparations in response to a nuclear threat. Emergency planning requires a holistic approach, or integrated preparedness for all emergencies.

In conjunction with development of these plans, we are also involving cities within our county, private industry, schools, military installations and adjacent counties. We also have close working relations with the State of Nevada, particularly Clark County, in coordinating emergency matters. During the recent hotel fire disaster in Las Vegas, our county provided back-up resources from law enforcement helicopter airlift and from our medical emergency teams who were held on standby for emergency assistance to burn victims.

As part of our emergency response effort, we are also planning to develop a "regional emergency operations and education center" in the northern part of our central valley area to serve this region as a headquarters for both emergency operations and communications during disaster, and as a training center to educate government and industry representatives from the southern California area, in all aspects of emergency preparedness.

A major objective of this regional center will also be to provide training and implementation of civil defense measures should that program be upgraded as has been considered recently at the Federal Level.

We are extremely gratified by the support and assistance we have received from the military jurisdictions in our area. In past emergencies, we have had close coordination and support from the Barstow Marine Base, 29 Palms Marine Base and George Air Force Base. Representatives of Norton Air Force Base are actively participating with us in the SCEPP Project and have a representative on our task force.

One other aspect of our southern California earthquake preparedness project which is indeed encouraging is the high level of participation we are receiving from the private sector. Our chamber of commerce and the news media are all working closely with us in developing these plans and are helping to disseminate information to the general public, business and industry.

In support of both earthquake preparedness and civil defense programs, we are also developing "neighborhood watch programs" which are "piggybacking" on law enforcement crime prevention programs already started in the county and in several of our cities.

We plan to use these neighborhood watch programs to disseminate information on emergency preparedness, to train individual citizens and to develop a capability at the neighborhood level of people caring for each other and sharing resources during disasters.

In the event the national civil defense program is revitalized, it should be recognized that civil defense is best carried out when it is part of an ongoing, highly localized program of overall emergency preparedness. I would hope that future funding of our scarce Federal preparedness dollars are apportioned in that way. Jurisdictions which are prepared for local emergencies can most easily cope with national disasters.

I have attached some back-up information to the prepared statement which may be of interest to you. Included is our February 1982 status report on the SCEEP earthquake project and a project overview describing plans for the regional operations center.

In summary then, San Bernardino County is deeply involved and actively engaged in developing earthquake preparedness for our area, but the effect of such a disaster will extend far beyond the boundary of our county and even our State. The response to such a disaster will require more aid than can be provided by local and State Governments.

Our efforts in emergency preparedness are increasingly difficult to continue with our dwindling local resources. Part of this is due to the need for more extensive research and development of earthquake technology which can only be accomplished at the Federal level.

We hope that the scientific community will continue to receive funding to expand their research and technology so that at some point in the near future we might have valid prediction models to forewarn us of imminent disasters of this sort.

Finally, I would like to reiterate that emergency planning involves many different contingencies of which earthquakes are only one. Future funding for emergency preparedness would be more effective if it addressed all level of preparedness, including local emergencies, regional disasters such as a San Andreas Fault earthquake and national emergencies such as a nuclear attack.

We would like to see a national emergency preparedness program which would assist local and state governments in developing comprehensive emergency response plans.

I think this would be a more acceptable way of preparing the public for disaster and a practical transition to real civil preparedness than embarking on a new "civil defense program".

I thank you for this opportunity to appear before you. I would be pleased to answer any questions you may have.

Mr. WALGREN. Thank you very much, Mr. McElwain. We especially appreciate your testimony inasmuch as you are so involved in local government. The more we see at the Federal level, the more we rely on the local level. You make a very important contribution and we thank you.

Mr. MCELWAIN. Thank you.

Senator SCHMITT. I could not see a thing in his testimony that I did not agree with.

Mr. MCELWAIN. We have got a lot of experience in earthquakes.

Mr. WALGREN. The last witness, Mr. Delbert Ward, is associated with Structural Facilities, Inc. from Salt Lake City. Mr. Ward, we appreciate your coming. We will try and observe the 5-minute rule and hopefully get to questions quickly.

STATEMENT OF DELBERT B. WARD, VICE PRESIDENT, STRUCTURAL FACILITIES, INC.

Mr. WARD. Thank you. It is a pleasure to accept the invitation to present this statement to the subcommittees and I want to express my thanks at the beginning for that.

At the outset, I wish to state that I favor and encourage reauthorization of the Earthquake Hazards Reduction Act of 1977. There are two compelling reasons for this. First, the 1977 act has been successful, in my view, in advancing goals for earthquake safety. The successes outweigh the few program problems that are discussed in more detail in my written statement.

The second is that there is much yet to be done in earthquake hazards reduction. My view is that the needed things will not be done without a continuing and strong Federal leadership.

My written statement, which I will abbreviate in this presentation, is built upon a 4-year experience that I had directing the State of Utah's Seismic Safety Advisory Council. It is from that association that I can point to successes that I see in the national act. Foremost for me is the fact that it—the act, that is—contributed heavily to the information sources that we necessarily had to draw upon in doing our work in Utah.

We were completely dependent upon the work outside of Utah because I think, like most other States outside of California, we had little experience, little research information, and little knowledge of how to proceed. We borrowed very heavily. We especially utilized the resources of the U.S. Geological Survey and the National Science Foundation.

I will not describe the work of the Utah Seismic Safety Advisory Council directly but will leave it to your reading in the formal statement. It is from that particular work that I have several observations with respect to the Federal role and its involvement in earthquake hazards reduction.

My answer to the question of whether there is a Federal role in earthquake hazards reduction is a resounding yes. The information made available to Utah and its importance I have already stated. But there is an even more significant Federal role that pertains to initiatives by local governments. My colleague from California will allow me to except that State in my observations from what I have to say.

Although I have observed an increase in local earthquake safety efforts during recent years, I also must observe that there is a difference between effort and adopted policy. In my view, there is no strong evidence that State and local governments are ready to deal with earthquake safety through policy actions.

Note, for example, that the State of Utah, after 4 years and a $.5 million effort, has not yet adopted the recommendations that were made by the body appointed to study the problem, and I cannot name many other local areas outside California where any such policies have been adopted. This condition will continue, in my judgment, unless a sustained Federal participation is present in the coming years.

It would be easy to take the position that Federal participation should be made available only insofar as a local effort is made. Such a position, unfortunately, fails to meet the need for coping with earthquake hazards. Earthquake safety in regions of less risk, but still significant risk, must be nurtured for a little longer, I believe, until a broader understanding of the risk is achieved and some local actions are taken.

I believe there are activities appropriate for Federal participation that need not encroach upon local government prerogatives of self-determination and still would contribute significantly to improved earthquake safety. One partner for such activities is the private sector, where already much has been accomplished in recent years—that is, private businesses and organizations in architecture, engineering, building, planning, and codes and standards. In fact, it is my opinion that more will be accomplished in implementing earthquake safety knowledge on a national scale during the next few years by the private sector than we can expect from policy actions by State and local governments. Given this particular point, I again stress that there is indeed a Federal role.

I want to jump now to the last portion of my written statement, which contains some suggestions that deal with strengthening of the present act in terms of any subsequent programs. I have listed in the paper three problems and three basic suggestions. I would like to go through these just briefly.

Problem 1: Technical knowledge concerning earthquake hazards reduction is significantly ahead of application of the knowledge. My suggestion is that increased attention be given to applications-oriented research and to implementation strategies for using our available knowledge. We know more than we are capable of using, in my judgment. However much as the researchers may think that we do not know enough, we still are not using what we know. We must strengthen our applications-oriented effort.

I note in the written paper that I am critical of the failure of the National Science Foundation to give needed attention to applications-oriented research. I suggest that if NSF is not comfortable in the dual role of basic and applied research that perhaps the subcommittees should examine again a proposal made by Representative Brown a few years ago to establish a National Technology Foundation as another means to get at that particular problem.

Problem 2: I note that there is an absence of aggressive leadership by the Federal Emergency Management Agency in fulfilling the purposes of the 1977 act. My own view is that the FEMA earthquake program has been buried within that large agency rather than given a highly visible emphasis that I believe is needed to increase earthquake hazards awareness. I also contend that attention given to the issue has been mostly in preparedness response and recovery, leaving mitigation as the stepchild.

My view is that there is much more to be accomplished in the arena of mitigation than we have been able to achieve to date. It needs attention.

In my opinion, FEMA is still the most appropriate agency to provide that leadership that we have talked about. My suggested solution to the problem, then, is reorganization of the agency aimed at bringing the earthquake program to an enhanced level of visibility and to a new level of influence in the agency's management structure.

I make one more suggestion pertaining to the FEMA program efforts. This relates to the traditional activities and sectors of interaction associated with disaster response planning. Earthquake hazards reduction involves new activities, interactions and disciplines that heretofore have not been involved in the typical and traditional disaster response planning.

FEMA must be urged for form the needed cooperative interrelationships in the new sectors and also to bring staff aboard who have broader knowledge and range of understanding that goes beyond traditional disaster planning and response planning types of activities.

Problem 3: State and local political structures seem to me to be much too unreliable to mount sustained long-term earthquake safety policy and efforts. This is a statement that some may disagree with, but my observation is that there are policy vascillations by State and local governments which mean that long-term commitments and efforts necessary for successful earthquake programs cannot be counted upon. These observations argue again for a strong Federal involvement in the activity.

My suggestion to deal with this third problem, in terms of the 1977 act and its reauthorization, is that the Federal programs should not be framed so that the Federal participation is contingent upon participation by State and local governments because to do so may cause you to do nothing.

Thank you very much.

[The statement follows:]

STATEMENT OF DELBERT B. WARD, ARCHITECT, VICE PRESIDENT, STRUCTURAL FACILITIES, INC.

This opportunity to present my views concerning reauthorization of the Earthquake Hazards Reduction Act of 1977 is both a privilege and an honor for me. I wish to thank the two subcommittees who have joined together to conduct this hearing for inviting me to make this statement.

At the outset, I wish to state that I favor and encourage reauthorization of the Earthquake Hazards Reduction Act of 1977. There are two compelling reasons for this. First, the 1977 Act has been successful nationwide in advancing goals for earthquake safety. The successes significantly outweigh a few program problems that are discussed later in this statement. Second, there is much yet to be done in earthquake hazards reduction. My view is that the needed things will not be done without a continuing and strong federal leadership.

In the remainder of my statement, I shall elaborate upon these two views. In doing so, I draw upon experience as a private practitioner in the building industry, and as a partner in an architecture and engineering firm which seeks to implement many of the concepts developed through government and private sector participation in earthquake safety efforts. I also draw upon experience from nearly four years spent developing earthquake safety public policy in Utah where I served as Executive Director of its Seismic Safety Advisory Council. The last-named experience has been especially helpful to me in understanding the importance of a comprehensive, coordinated, and sustained effort to advance our capability and our readiness to deal with problems of large earthquakes.

SUCCESSES OF THE 1977 ACT

While I cannot in candor say that all goals of the 1977 Earthquake Hazards Reduction Act have been met, it also would be incorrect to conclude from particular criticisms I shall offer later that the Act has not been beneficial. Some of the benefits that I have experienced and observed merit brief comment.

Utah seismic safety policy efforts

The State of Utah authorized that work begin to develop a comprehensive statewide earthquake safety policy in 1977 at about the same time the Earthquake Hazards Reduction Act was authorized. This state authorization, like the one at the federal level, actually developed its momentum during the few years prior to 1977. However, in Utah, unlike some agencies within the federal government, we had almost no prior experience, little research information drawn directly from earthquake conditions within the state, and almost no prior involvement in earthquake hazards reduction that might be used as a foundation for our work. That foundation had to be built using the experiences and information developed by others outside Utah, notably from materials produced through federally supported efforts and from work in the State of California. We borrowed extensively from such information resources throughout the entire work period of the Seismic Safety Advisory Council. The important point here is that Utah received valuable guidance from the efforts of others whose work, for the most part, was not aimed at earthquake problems in Utah. Nonetheless, the information and analytical models prepared for other purposes were transferable and extremely valuable to us.

Both initially and during our later years, the Utah program was dependent upon much good and pertinent work by the U.S. Geological Survey (USGS), by the National Science Foundation (NSF), and by our more experienced counterpart, the California Seismic Safety Commission (CSSC). Without the USGS estimates of earthquake risk and methodologies for evaluating Utah's risk conditions, without the NSF-sponsored research papers dealing with various aspects of earthquake effects, and without the CSSC formulations of earthquake safety policy which we reviewed so carefully, the work in Utah would have progressed much more slowly and much less reliably. Although we sometimes had to adapt the information to fit Utah earthquake conditions and had to expand some information for greater utilitarian value, we still learned very quickly that earthquake experiences, research, and information are beneficially transferable from one region to another.

As a consequence, we successfully completed our legislative charge on schedule in Utah and at the end of four years delivered to the Legislature and to the Governor a detailed analysis of earthquake risk in the state along with some very specific policy recommendations that we believe would serve the people of the state, safeguarding both their lives and their property from earthquake loss. We now are in a period awaiting executive action by the Governor and legislative action on our recommendations.

Parallel activity in other States

It is my observation that other regions and states also have benefited from the national commitment to earthquake hazards reduction in 1977. Earthquake safety policy efforts are underway today in locations where there were none in 1977. These are local and regional efforts, aided and encouraged by federal agencies authorized and obliged to do so by the 1977 Act. Without naming specific examples, one obvious conclusion to be drawn from the observable increased attention to earthquake hazards is that the Earthquake Hazards Reduction Act of 1977 has been instrumental in elevating the awareness of many people to the nature and degree of earthquake risk in their respective locations.

Earthquake hazards and a Federal role

The above observations provide a basis for my response to two questions that, no doubt, have importance to this hearing for reauthorization of the 1977 Act.

> Is earthquake safety more than a regional problem and more than a problem that affects only California?

My answer to the question is a resounding "yes." One cannot review the available literature and reach any other conclusion. Earthquake hazards occur throughout much of the nation; only the degree of risk varies. Moreover, the economic and social structures of the individual states are so intertwined that a damaging earthquake in one location would be expected to impact the economic and social fabrics of other locations, even in other states. Earthquakes do not respect political boundaries; neither do their potential impacts.

> Is there a federal role in earthquake hazards reduction?

Again, my answer is a resounding yes. The importance of federal initiatives involving research and information made available to the Utah earthquake safety policy effort already has been noted. But an even more significant federal role is suggested here that pertains to initiatives by local governments. Although I have observed an increase in local earthquake safety efforts during recent years, I also must observe that there is a difference between "effort" and "adopted policy." In my view, there is no strong evidence that state and local governments are ready to deal with earthquake safety through policy actions; yet earthquake safety public policy is one important way by which hazards reduction can be accomplished. Note, for example, that Utah has not yet adopted the policies recommended after substantial work by an eleven-member advisory council, and I cannot name many other local areas outside California where any such policies have been adopted. This condition will continue, in my judgement, unless a sustained federal participation is present and continues in the coming years.

It would be easy to take the position that federal participation will be made available only insofar as local effort is made. Such a position unfortunately fails to meet the need of coping with earthquake hazards. Furthermore, such a position could result in a federal program benefiting primarily California which to date is the only state to enact earthquake safety public policies in an aggressive manner. Earthquake safety in regions of less, but still significant seismic hazards, must be nurtured for a little longer until a broader understanding of the risks is achieved. The Federal government is an appropriate supplier of this nourishment.

I believe there are activities appropriate for federal participation in earthquake hazards reduction programs that need not encroach upon local government prerogatives of self-determination yet would contribute significantly to improved earthquake safety. One worthy partner for such activities is the private sector. Much has been accomplished toward earthquake hazard reduction in recent years through the private sector—e.g., private businesses and organizations involved in architecture, engineering, planning, geotechnical engineering, geology, and building codes and standards. Individual and collective efforts among members of these groups have been assisted as a result of the 1977 Act, and still more can be done. Indeed, it is my opinion that more will be accomplished in implementing earthquake safety knowledge on a national scale during the next few years by the private sector than we can expect from policy actions by states and local governments.

The implication that state and local governments are sluggish in responding to earthquake safety suggestions need not cause alarm, however, because I also hold the opinion that a great deal can be accomplished by the private sector for earthquake hazards reduction simply by incorporating present knowledge into building and planning practices. Mitigation of earthquake risk is very much an activity appropriate for the private sector, even though preparedness and response activities are better suited for governmental units. Given this observation, there is a greater Federal role in earthquake safety than one might think.

Several private-sector organizations have provided and are capable of offering meaningful contributions toward meeting the goals of the 1977 Act. The Earthquake Engineering Research Institutes (EERI), comprising practitioners, researchers, and scientists, perhaps has contributed more to broadened earthquake safety knowledge than any other organization, including both governmental and private-sector organizations. The American Institute of Architects (AIA) supported the original 1977 Act and continues its commitment to broaden the knowledge of its membership concerning earthquake-resistant design. Attention is called to an attachment to this statement by the AIA which reaffirms that organization's commitment to improving design practices for earthquake safety. The American Planning Association recently released a document explaining good planning practices for earthquake safety, and a special committee on lifelines engineering for earthquake safety has been formed within the American Society of Civil Engineers. Similarly, organizations that develop and promulgate building codes and standards have given increased attention to earthquake hazards reduction. These activities are significant because it is within these disciplines where real changes in earthquake safety practices are implemented, with or without the participation of governments.

STRENGTHENING THE 1977 ACT

Nothwithstanding my previously stated favorable view of the 1977 Earthquake Hazards Reduction Act and accomplishments under the Act, all is not completely well with the specific program efforts to carry out the purposes of the Act. I wish to identify some of the problems as I see them, and to suggest some adjustments that I believe would strengthen any subsequent programs.

1. *Problem: Technical knowledge concerning earthquake hazards reduction is significantly ahead of application of the knowledge.*

   Suggestion: Increased attention to application-oriented research and to implementation strategies for using our available knowledge is essential.

Although efforts such as the Southern California Earthquake Planning Project are valuable, including the potential value of transferable experience gained, and such as the USGS regional earthquake safety policy seminars, these are not enough to narrow the gap between research and application. The development of basic engineering and geotechnical knowlege still outstrips our capability to utilize the knowledge. It is an unfortunate condition of our times that real world planning and design practices and public policies change more slowly than does our technical understanding. This situation must be recognized, and appropriate programmatic adjustments ought to be made in earthquake safety efforts to speed up these processes. A colleague of mine has observed, quite correctly I believe: We know how technologically to reduce earthquake risk to lives and property; now let's get it done.

With respect to the above paragraph, I am especially critical of the failure of the National Science Foundation to give the needed attention and resources to application-oriented research. While I am aware that the mission of NSF is basic research, this does not erase the need for more practical studies pertaining to earthquake safety, nor does it replace an implied obligation that NSF has under the current Act. If NSF is not comfortable in the dual role of basic *and* applied research, then perhaps the subcommittees participating in this hearing should examine again a proposal made by Representative George E. Brown, Jr., a few years ago to establish a National Technology Foundation whose mission would be more explicitly directed to applications of technology.

2. *Problem: Aggressive leadership by the Federal Emergency Management Agency in fulfilling the purposes of the 1977 Act has not been apparent to some of us.*

FEMA is designated as the lead agency for coordinating federal activities in fulfillment of the 1977 Act; yet in my view, that agency seems to have been a reluctant follower of other agencies rather than an innovative leader. My own view is that the FEMA earthquake program has been buried within that large agency rather than given a highly visible emphasis that I believe is needed to increase earthquake hazards awareness. Moreover, the attention that has been given to the issue has been mostly in preparedness, response, and recovery, leaving mitigation as a stepchild. The view among many of us who have given effort to earthquake hazards reduction is that there is more to be accomplished in earthquake hazards reduction through mitigation than through any of the other activities. Finally, it seems to me that the lead agency should be recommending a range of programs to the Congress, along with appropriate funding requests. In fact, FEMA has put forth only modest program requests during the last few years. It is a fact of government processes at all levels that programs will not be authorized or funded until they are presented to the legislative bodies. My view is that FEMA has failed in this regard.

Suggestion. My opinion is that FEMA still is the most appropriate agency to provide leadership for federal earthquake safety programs. My suggested solution to the problems cited above is a reorganization of the agency aimed at bringing the earthquake programs to an enhanced level of visibility and to a new level of influence in FEMA's management structure. If these two things were done, I believe we would see significant forward motion toward meeting the goals of the 1977 Act.

I would make one more suggestion pertaining to FEMA program efforts for earthquake hazards reduction. My view is that activities pertainng to earthquake hazards as well as to the local sectors of interaction are much broader than the traditional activities and sectors of interaction associated with disaster response planning. While these traditional activities and interactions also are important for earthquake safety, there is more that needs to be done in the area of mitigation, and there are new intercooperative relationships that must be formed. Mitigation efforts typically require the participation of parts of government and the private sector which heretofore have not interacted with disaster response planning efforts, and I have observed only minimal success by traditional disaster planners to understand these differences and to work in the broader manner needed for earthquake safety programs. Accordingly, the suggestion is made that FEMA seek to employ personnel with expertise in the broader issues of earthquake safety rather than simply reassign and rename disaster planners. A further suggestion is that FEMA seek to encourage similar effort by local disaster planning agencies.

3. *Problem: State and local political structures seem to be much too unreliable to mount sustained, long-term earthquake safety policies and efforts.*

For a variety of reasons, long-term commitments and efforts seem necessary to correct risk conditions resulting from many years of neglect. The characteristics of earthquakes—e.g., the many years between severe occurrences, and an unpredictable (so far) distribution of events in time and space—do not fit well with our typical political processes in which planning today for problems that might occur during some future elected official's term of office is the exception rather than the rule. It does not really matter what each of us individually might feel about this situation; what matters is that local political processes do tend to accept expediency over solid solutions to problems.

Suggestion: Given the situation briefly stated in the preceding paragraph, federal earthquake hazards reduction programs should not be framed so that federal participation is contingent upon participation by state and local governments. Although participation by all levels of government is desirable, it may not always occur, or it may occur only sporadically. However, governmental participation (or nonparticipation) does not alter the earthquake risk, and that risk is much too serious to set conditions for federal efforts that might constrain valid program activities. As I have noted earlier in this statement, federal resources and capabilities can be beneficially mobilized regardless of the extent of local participation, and there are partnerships within the private sector that, appropriately nurtured, can contribute to enhancement of the nation's ability to cope with earthquake hazards.

CONCLUSION

While the observations and suggestions made in the preceding paragraphs touch upon only a few of the many things that might be said about the progress of earthquake hazards reduction efforts in the nation, they are among the most pertinent to the purposes of this hearing. It is hoped that the comments will be helpful to the subcommittees. I have found this to be a stimulating and thought-provoking opportunity for which I once again extend my thanks.

Mr. **Walgren**. Thank you very much, Mr. Ward. We certainly appreciate the statement.

Senator Schmitt.

Senator **Schmitt**. Mr. Chairman, I am about to have to leave for the floor. I appreciate the testimony of our last group of witnesses, certainly more frank and up front than what we had from some of the previous ones, and I can understand the differences.

There is no question in my mind that the local and State organizations right now will bear the principal burden of any earthquake-related disaster that might occur because the Federal Government is not prepared to move in any major way to assist, except as assistance has already been worked out, as in the case of California, with the local Federal installations, particularly military installations.

It is my own hope that we can see a far stronger relationship develop between civil preparedness organizations in the State and local governments and the National Guard Reserve units. I think there is a great deal that can be done there to develop an even greater sense of mission than those units already have and is not inappropriate in terms of actual civil defense training that could come with the assistance of those organizations.

I guess the one final question I would have for you gentlemen is do you really believe that we can ever get FEMA to concentrate on this problem, or should we find some agency that can concentrate on the applied side of it, such as NOAA concentrates on weather? There really are some similarities in the application of basic research to weather forecasting and services as we are now faced with in the case of earthquakes.

Mr. McElwain.

Mr. **McElwain**. Yes. Terry Meade is the gentleman that we deal with in San Francisco and I have gotten excellent cooperation from him. Whatever the beckon may be, he is there and I appreciate that. I have not dealt with the people here in Washington or any other State.

I think that the role can be executed and executed well by FEMA with the people that I am familiar with, and I might say that in the area I am speaking from, our local government in southern California, we are not only ready to act, even though our plan prototype will not be on line until December, we are in place to move if it happened tomorrow.

Senator **Schmitt**. I think that is why you are having such good relations with FEMA. You set up something they can cooperate with and that is what I meant.

I think the burden right now is really at the local level, until we get something going at the national level, if we do.

Mr. **Pinkerton**. Senator Schmitt, in response to your question as it relates to building construction, in all due fairness to the FEMA organization, my observations and opinion, for whatever it is worth, I think that area of responsibility should be transferred to the National Bureau of Standards Center for Technology in that they have not only the resources but they also have the number of technically qualified individuals and that that then could be coordinated with other actions that FEMA relates to, as after a catastrophe, and that could work out really well.

But I think we have got the program of building safety in the wrong area.

Senator SCHMITT. Mr. Ward.

Mr. WARD. Yes, Senator, I would like to respond to expand upon my comment in the written statement. I still believe that FEMA can be structured to do the job. I think it is an appropriate agency and particularly I think that it fits into the State structures where you also have to work.

There is a traditional structure at the State levels and local levels that is built around hazards reduction from other natural events and the civil defense effort. I think that to try and build another structure at the Federal level does not make sense yet.

I would call attention to one statement from my written paper. FEMA has put forth only modest program requests pertaining to earthquake hazards mitigation during the last few years. My observation, from having been involved in State government, is that it is a fact of Government processes at all levels that programs will not be authorized or funded until they are presented to the legislative bodies.

So again it is a jacking up, I believe, more than a throwing out.

Senator SCHMITT. Dr. Thiel.

Dr. THIEL. That is a very provocative question. Frankly, I doubt that any other agency could pursue preparedness-related activities, but I share with my colleagues some concern over whether they indeed can run a national program and apply the expertise, budgetary resources, and the like that are required to run an integrated program.

In fact, it is not clear to me when budgets are constrained and agencies are free to take independent actions that overall program direction and momentum can be maintained without a single budget managed by a single agency with an overall program responsibility and staff competence.

I think the Congress could shift serious consideration to consolidating the entire budget under one agency, providing the financial resources there and then give to them the responsibility of allocating those funds among several agencies which have particular missions under this act. In this way we might have a chance of getting a more coherent, more results-oriented and hopefully livesaving program in place.

Senator SCHMITT. Thank you, gentlemen.

Mr. WALGREN. Thank you, Senator. I appreciate it.

Senator SCHMITT. Maybe we can get some more geologists to run for public office.

Mr. WALGREN. Well, they are going to follow your example.

Senator SCHMITT. Not very many of them.

Mr. WALGREN. Mr. Brown.

Mr. BROWN. Let me say that I appreciate also the contribution of this panel. It is very difficult in having representatives of the executive agencies to get anything critical from them of the level of resources which they are constrained to accept and the programs which they are involved in.

I am inclined to feel, based upon my own observations and your testimony, that perhaps FEMA still is the best agency to provide overall coordination, but perhaps we should restructure this a little bit so that the agencies, such as the Bureau of Standards or NSF play a more aggressive role in the areas that they are concerned with.

I would hope the committees will review that aspect of it. Obviously what we need and what we had hoped to get in writing this bill originally, however, was aggressive leadership from FEMA, and while it is a little early to say that they have either succeeded or failed at that, that is an ingredient which is vital to the success of a program such as this. I hope there is no disagreement from any of you on the importance of that.

The point that Supervisor McElwain made about this being, the earthquake hazard program should be part of a comprehensive effort at hazard mitigation and hazard response has always seemed to me to be extremely important.

I would like to inquire if there is any disagreement with the need to treat it in this fashion, at least not as far as earthquake research is concerned, but in terms of the preparation and postcatastrophe response and so forth.

Dr. Thiel.

Dr. **Thiel**. While there is a great deal of similarity between the types of events, I think that one of the reasons that we are in a bit of a bind right now in responding to major earthquakes is that we are relying upon the fact that we can respond to relatively modest tornados and hurricanes and floods—at least modest by comparison—as an indicator that we can successfully cope with the problems presented by earthquakes.

I think insofar as such a combination of programs would lull us into that kind of false sense of security, it could be very deleterious. On the other hand, I do support the fact that we are losing massively as a society from other types of hazards, that we are not addressing those other hazards, be they floods or winds or whatever, in a very coherent way.

There is great benefit in combination.

Mr. **Brown**. Well, there are problems in making an effort to combine all these various kinds of disasters also. One that occurs to me based on this discussion is the relationship between earthquake and major fire disasters. They are likely to come together, as a matter of fact, when they come. An earthquake is likely to produce major fires, as happened in San Francisco in the early part of the century.

And yet FEMA has a responsibility for fire research and for fire training and some other things related to it. There is an institutional difference, however, in that there is a very local responsibility for fire and the basic capability to respond is at the local level. There is no such similar institutional arrangement for earthquake.

Most local agencies do not really consider earthquakes to be a matter of their ongoing institutional activities, other than their connection with the remote possibility of a major disaster, in contrast with an ongoing fire program.

Now this is likely to cause FEMA to have some problems in developing a coordinated approach unless they have a very broad vision of the nature of their mission as an overall Federal manager for disaster response. And if they see that broad role, then they can see not only the differences but the relative similarities between fire, nuclear attack, earthquake, flood, volcanic eruptions.

There are commonalities in all of these things which need to be considered.

Mr. **WALGREN**. I had wanted to yield my 5 minutes to the gentleman from California.

Mr. **BROWN**. What you are getting is a speech from me more than a question.

What I am trying to do is help to motivate FEMA to have this broad view of the significance of this overall mission and the importance of earthquakes as being a tool by which they can perfect a number of these total programs.

Now let me just ask the panelists here if this approach or philosophy, which I have had for a number of years, still conforms to reality, or am I trying to do the wrong thing.

Mr. **MCELWAIN**. I would like to respond. I think it is almost impossible to separate the disasters in the sense that we are talking about them. They may all happen differently and maybe even have responsibilities on different levels, but we are talking about the same thing. We are talking about damages to property, the lifeline to the public that we represent, and the people—death, injuries and so forth—and they all are handled in the same manner.

When you get off of the context of the fact that the disasters have a similarity you actually lose your effectiveness in doing what you want to do. We plan to put together a program that is second to none in southern California that is going to respond, including Los Angeles, Ventura, the southern California area—a 60-mile radius. We think that can happen. We think it can be done. We have an airport there, a place to put it. All we have to do is turn the key and open it up, and that is why we are looking in that direction.

We are really concerned about earthquakes. We understand the predictions and we are listening to the seismologists, the geologists, people that are looking at them and predicting. We are saying that we want to be ready for anything that happens. We are using earthquakes at this point because it is prominent within the near future to do what we need to do for all the disasters may happen.

And I think with all that in mind you have to go back to reality and say whenever there is damage to property, whenever there is lives you have to use the same tactics because you are going to be saving the same people and the same property and it doesn't really separate itself.

Mr. **BROWN**. Thank you, Mr. Chairman.

I think in view of the time, I will stop.

Mr. **WALGREN**. Well, thank you, Mr. Brown. I have nothing further.

I want to express my appreciation to the witnesses. You have given us several independent tracks on earthquake hazards reduction and that is very helpful to all of us. Mr. Brown, of course, has had the major interest in this area for years and has certainly gotten the attention of many in the Congress on this issue.

We certainly do appreciate the guides you have given us and your outstanding testimony has provided valuable background for the fiscal year 1983 reauthorization of the Earthquake Hazards Reduction Act. Thank you very much.

[Whereupon, at 12:47 o'clock p.m., the subcommittees adjourned.]

[The following information was subsequently received for the record:]

NATIONAL INSTITUTE OF BUILDING SCIENCES,
Washington, D.C., March 11, 1982.

Hon. HARRISON SCHMITT,
Chairman, Subcommittee on Science, Technology, and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

DEAR SENATOR SCHMITT: I appreciate the opportunity to submit written testimony for the record on the occasion of this joint House and Senate authorization hearing on the Earthquake Hazard Reduction Act of 1977 (Public Law 95-124). I am doing this on behalf of the Building Seismic Safety Council (BSSC) of which I am the newly elected Chairman.

The BSSC was created in 1978 as an independent, voluntary body under the auspices of the National Institute of Building Sciences (NIBS), which itself was created pursuant to an Act of the Congress (Sec. 809, Title VIII, Public Law 93-383). BSSC has as its mission the furtherance of the objectives of Public Law 95-124 and the President's Earthquake Hazards Reduction Program of June 22, 1978, that flowed from that law. The stated purpose of BSSC is to enhance the public's safety by providing a national forum to foster improved seismic safety provisions for use by the building community—i.e., by all those involved in the planning, design, construction, regulation, and utilization of buildings. Included are consideration and assessment of the social, technical, administrative, political, legal and economic implications of such provisions. Involved are representatives of Federal, State, and local units of government, the design professions, the construction industry, the research community, and the public. The BSSC Charter and Organizational Rules and Procedures, as approved by the NIBS Board of Directors, is appended as Attachment A.[1]

It is important to note that BSSC has adopted a number of objectives that deal not only with seismic safety research and the development of cost-effective seismic safety regulatory provisions for buildings, but with moving these provisions into the regulatory process, and promoting both research and practice so as to ensure that the benefits of research and experience are continually translated into prudent action. BSSC, therefore is committed to the pursuit of those aspects of the program that deal directly with the design and performance of the nation's buildings.

In its endeavors, BSSC has worked closely with the Federal Emergency Management Agency since its inception as an independent agency and its acceptance of responsibility for the seismic safety program. During its formative stages, BSSC was funded by NIBS—in fact the Institute has spent nearly $68,000 of its discretionary funds to bring the Council to a viable working status. NIBS also was able to get the Federal National Mortgage Association to make a grant of $20,000 to help in this effort, and through its own dues structure, annual meetings, and contributions from its members, BSSC has itself been able to raise an additional $54,860 for its basic support and activities.

The principal undertaking of the Council to date has been the assessment and refinement of the Tentative Design Provisions for the Development of Seismic Regulations for Buildings (more popularly known as ATC 3-06), prepared by the Applied Technology Council. A summary of the history of this work and future plans is shown in Attachment B. FEMA has provided support for this work totalling $231,584 to date. The next step is the conduct of trial building designs to determine the practicability of the refined ATC 3-06 provisions. The ultimate objective is to develop and ballot a final set of design provisions that can be recommended and then fostered for adoption and use by all regulatory jurisdictions and the private sector.

There has been an unfortunate 15 months hiatus in support for this work by FEMA; nevertheless, through the voluntary efforts of the BSSC membership, working with FEMA and the National Bureau of Standards, it has been possible to move the program plan to an even more refined state of readiness. We are advised by FEMA that it fully intends to fund the start up of the trial design work in the very near future using its limited fiscal year 1982 funds, and that it hopes to fund completion of this phase of the work in fiscal year 1983, assuming funds are appropriated for it to do so. Although this will stretchout the work longer than we had anticipated, the trial design work still can be kept viable so long as there is no lack of continuity between the fiscal year 1982 and fiscal year 1983 work. In the current year, for example, trial designs are planned for Los Angeles, Memphis and Seattle; next year the remaining representative cities—Phoenix, Chicago, Minneapolis and New York—will be added. The important thing is that for comparative purposes, all trial designs need to be conducted within a reasonable time frame.

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[1] The attachment is in the committee files.

In conclusion then, BSSC is hopeful that the Congress will continue this program which enjoys such wide support and participation. It is hoped also, that the Congress will continue to look to FEMA to provide the leadership and the coordinating function at the Federal level, and that it will provide FEMA with the financial resources and the ability to participate in the programmatic process of those federal agencies involved in the program. BSSC would ask that the Congress also encourage all interested parties, both public and private, to participate in BSSC in the interest of developing a nationally acceptable posture on seismic safety design and construction requirements, be they Federal, State or local. Finally, BSSC would hope that the Federal Government will continue to look to BSSC to coordinate State and local government and private sector input to the overall earthquake hazards reduction program as it relates to housing and buildings.

Sincerely,

ROY G. JOHNSTON,
Chairman, Building Seismic Safety Council.

ENHANCING SEISMIC SAFETY IN THE CENTRAL UNITED STATES

(By Charles C. Thiel, Jr.,[1] and Ugo Morelli [2])

ABSTRACT

The likelihood of a major damaging earthquake in the Central United States is assessed as sufficiently high to warrant long-term hazard mitigation and preparedness planning initiatives. A five-year program is formulated to: (1) Develop vulnerability analyses and identify opportunities for reducing damage, injury and disruption; (2) initiate a cooperative planning project among diverse local, State and Federal jurisdictions to deliver a comprehensive, integrated preparedness and mitigation program; (3) complete specific preparedness plans for critical facilities and interim plans for Federal and State governments; and (4) improve the knowledge of professionals, public officials and the general public on earthquake hazard reduction issues.

INTRODUCTION

Major earthquakes not only can occur in the east and mid-west—but they also have. The area on which this paper focuses, the Central United States, is one of them. As a matter of fact, the earthquakes that centered around New Madrid in the winter of 1811-12 have been called "unique in their awesomeness" by Dr. Otto W. Nuttli (1), who has devoted a great deal of study to the seismicity of this area.

Table 1 lists major earthquakes that have occurred in the United States since European settlement. This table uses the area subject to major damaging potential as a measure of the "size" of an earthquake. The first four of these events affected substantially larger areas than the balance. Fig. 1 illustrates the comparative size of the area impacted for these events compared to the California quakes.

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The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Federal Emergency Management Agency nor of any other entity in the public or private sector.

NOTE.—This paper is based upon a more extensive discussion of this topic in "An Approach to Seismic Safety for the Central United States," by these authors reprinted in the proceedings of the Conference on Earthquakes and Earthquake Engineering: The Eastern United States, Knoxville, Tenn., Sept. 14-16, 1981.

FIGURE 1
COMPARATIVE ISOSEISMALS
([1])

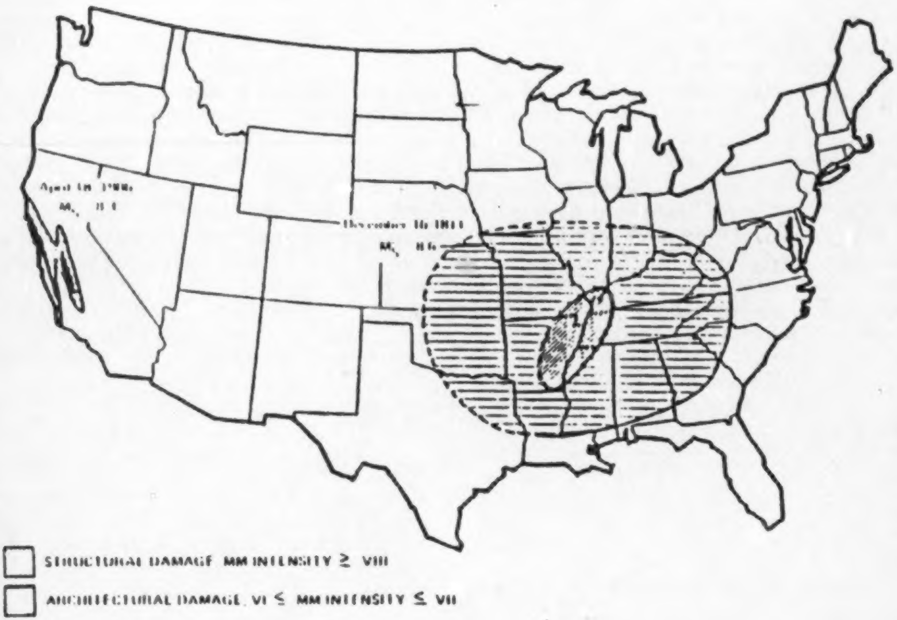
April 18, 1906
December 16, 1811
☐ STRUCTURAL DAMAGE MM INTENSITY ≥ VIII
☐ ARCHITECTURAL DAMAGE, VI ≤ MM INTENSITY ≤ VII

TABLE 1.—*Major U.S. earthquakes (2)*

Location:	*Year*
1. New Madrid, Mo.	1811
2. New Madrid, Mo.	1811
3. New Madrid, Mo.	1812
4. Charleston, S.C.	1886
5. Owens Valley, Calif.	1872
6. Fort Tejon, Calif.	1857
7. San Francisco, Calif.	1906
8. Hebgen Lake, Mont.	1959
9. Prince William Sound, Alaska	1964

The geology and seismology of the eastern and western United States are such that we expect substantial differences in the nature of damaging earthquakes in these respective areas. There are four geological and seismological characteristics of the Central United States that are very significant (1,3,4,5):

1. The ability to generate truly catastrophic earthquakes: Richter Magnitudes of 8 or higher. In the 1811-12 sequence, for example, three of the shocks were of magnitude 8 or greater with Modified Mercalli Intensity of x or higher.

2. Return periods of some 600 to 700 years for earthquakes of surface-wave Richter magnitude of 8.4 or greater. These periods have been established by an analysis of the historic seismicity of the area and by a recent intensive investigation, including the collection of seismic, aeromagnetic, gravity, geomorphic, tectonic, seismic refraction and reflection data, reflective profiling, and trenching. This investigation has associated the earthquakes in this area with an ancient intraplate rift that is buried under the Mississippi embayment and has had periodic tectonic and volcanic activities. Earthquakes of much lower magnitude but significant damage potential, and correspondingly greater frequency are expected.

3. Low Attenuation—because of geologic formations in this part of the North Atlantic Plate—of seismic waves of low frequency (1 to 10 cycles per second), with a

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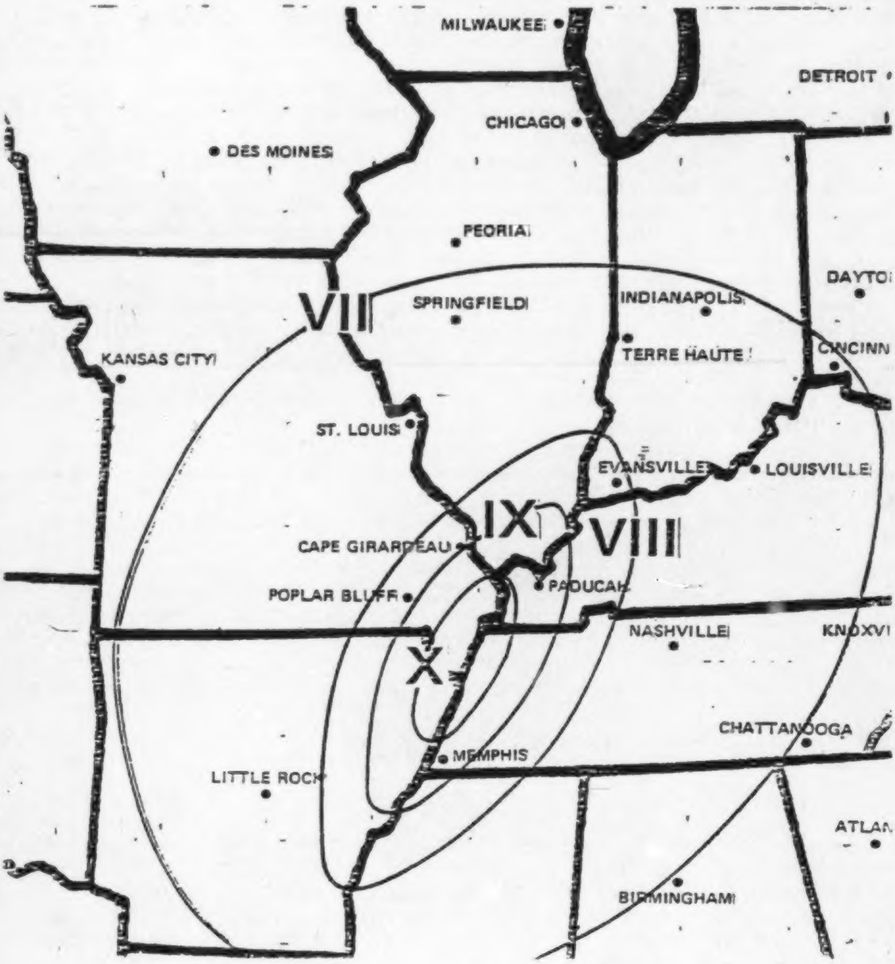
long period (1 to 4 seconds) of ground motion, thus potentially causing damage to long period structures (tall buildings at great distances).

4. Large aftershocks, possibly occurring for a few years. The 1811-12 sequence of three major events, and the occurrence of many smaller potentially damaging earthquakes for many years afterwards, is distinctly different from the California experience where aftershocks tend to be of smaller magnitude and occur for only a few months.

Earthquakes in the Central United States have the potential for damage and life loss larger than experienced to date from any U.S. natural hazard occurrence, whether from floods, hurricanes, or tornadoes. Figure 2 shows areas (MMI VII intensity) within which major damage may be expected to occur. A rough estimate prepared by Petak (6) of the building losses alone in the recurrence of the 1811-12 New Madrid earthquakes amounts to some $13-14 billion (1980 dollars). On the other hand, earthquakes in this part of the country contrast markedly with those in California with regard to the area in which damage occurs and the earthquake is felt. For approximately the same Richter Magnitude (8+), the area in which structural damage is likely to occur is at least five times greater in the Central United States than in California and at least 25 times greater for architectural damage—the kind that contributes heavily to both material and life losses (1). The greater area of impact means more complex and extensive mitigation and preparedness, involving a myriad of political and administrative jurisdictions and creating intergovernmental and managerial problems that have not been addressed, let alone resolved. The long-period character of ground motion requires preparedness measures for some structures (e.g. buildings over 10 stories high or very long buildings) in localities hundreds of miles away from the epicentral area, where no other significant damage of other kinds is likely to occur.

FIGURE 2 – NEW MADRID EARTHQUAKE - ISOSEISMALS FOR MMI VII AND HIGHER [1]



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In recognition of its risk for almost 50 years California and its local governments have required a series of progressively more stringent earthquake safety measures through land uses and building regulations. On the other hand, the Central United States has little history of legislation at the State level favorable to an improvement in the seismic safety requirements in building codes, professional practices, or land use regulations. With minor exceptions, most construction does not consider explicitly earthquake hazards and consequently has limited resistance. Public perceptions of eathquake hazards also are radically different in the two regions. "Everyone" in California knows that they are in "earthquake country;" however, few in the Central United States realize that major damaging earthquake can occur in their area and that steps to reduce vulnerability can be taken. These distinctions force a different view toward earthquake hazards reduction in the two areas, and particularly force a different approach for earthquake preparedness in the Central United States than that adopted in California. However, much of the specific content of California programs may be directly adoptable. Experience in earthquake hazards reduction in California, Nevada and Utah suggests three general observations:

Even in areas of high risk which are recognized by the public, there has been a long series of false starts in comprehensive earthquake mitigation programs.

Once programs are in place they may degrade quickly through misuse and or nonuse.

Every damaging earthquake has suprised us in major ways by damage which has or has not occurred.

This experience indicates that the objectives of improving earthquake safety and preparedness in earthquake-prone areas will be one that requires long and continuing efforts. Attempts at quick fixes are certain to fail.

Now let us turn to the significance of an earthquake in the Central United States. The area would experience the most serious impact of the earthquake lies astride the central valley of the Mississippi River and its major mid-stem tributaries, the Missouri and the Ohio. It includes portions of seven States. The total area of these seven States covers almost 10 percent of the country. The 1975 population of this same seven-State area was over 33 million people, or over 15 percent of the Nation's total. This area contains a significant segment of the National economy, with over 15 percent of the total employment of the country and almost 19 percent of the value added by manufacturing found there. In general, the northern portion of the area is heavily industrialized, with, Indiana and Illinois accounting for almost 40 percent of the total value added by manufacturing in the area.

A PLANNING APPROACH FOR THE CENTRAL UNITED STATES

An effort to improve earthquake preparedness that covers all the geographic areas that might be impacted and prepares for all the possible effects of a damaging earthquake will require an effort of substantial magnitude. To succeed there is a need to proceed in an incremental fashion, identifying segments that can be discretely addressed and time-phased within an overall grand plan for performance by government, professional organizations, business, voluntary organizations, and individuals. In this context, an initial five-year effort appears to be reasonable. Experience in other geographic areas emphasizes the necessity for close cooperation among all elements of government and the public in both the design *and* conduct of preparedness and mitigation programs. While recognizing this necessity for wide involvement, it is still useful to posit a program as an initial point of departure. Such a program should be formulated to achieve the following basic integrated objectives:

(I) Develop vulnerability analyses and identify opportunities for reducing damage, injury and disruption.

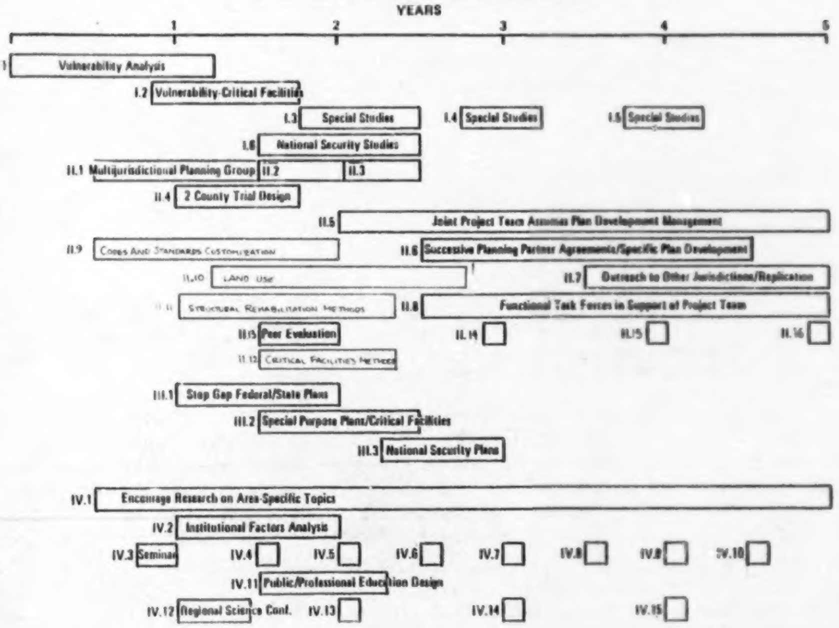
(II) Initiate a cooperative planning project focusing on building capability within diverse local, State and Federal jurisdictions and ultimately delivering a comprehensive, integrated preparedness and mitigation program among the affected institutions.

(III) Complete specific preparedness plans for critical facilities and interim plans for the Federal and State governments.

(IV) Improve the knowledge of professionals, public officials and general public on earthquake hazard reduction issues.

Fig. 3 presents a first estimate of the time sequencing of activities to accomplish these objectives. They are discussed sequentially below. While the diversity of individuals and institutions is not explicit on the chart, it must be understood that they are diverse, drawn from all levels of government and the diverse geographic and business interests likely to be affected.

FIGURE 1
DRAFT CENTRAL UNITED STATES
EARTHQUAKE HAZARDS REDUCTION FIVE-YEAR PLAN



Several analyses of specific earthquake problems for this region have been made in the past few years by Nuttli (1) and Wiggins (7). While each has been useful, to varying degrees, for focusing attention on the scope and nature of the earthquake problem in the region, they have not provided the detail required to make specific judgments for development of preparedness plans or mitigation strategies—only Wiggins has made preliminary estimates of the benefits (and costs) that would accrue if different mitigation strategies were adopted. These assessments must be augmented to ascertain the extent to the hazard, the nature of impacts and distribution of losses (Task I.1). Two aspects of these assessments are the measurement of vulnerability and estimates of the reduction in vulnerability of various program's implementation. The assessment vulnerability should yield estimates for isoseismal maps for potential life loss and injury, building damage and distribution, damage to lifelines, the likelihood of fire, and loss of services of key facilities (e.g. hospitals), which are vital in the post earthquake emergency response period, and damage to facilities (e.g., toxic chemical storage), whose failure could cause large secondary consequences. Models for these assessments have been prepared for San Francisco, Los Angeles, Puget Sound and the Salt Lake City areas (8), although more complete quantification of the specific benefits (costs) which might accrue based on adoption of different mitigation strategies need to be quantified. The focus should be upon the geological and seismological problems in those areas expected to experience MMI VII or greater. The vulnerability and adjustments phase of the analysis should proceed through the following sequence of ranked priorities:

1. Centers with 100,000 people or more in areas of anticipated maximum impact (MMI VIII and higher)—Little Rock, Arkansas; Evansville, Indiana; and Memphis, Tennessee. Casualties and dollar losses become truly substantial in the area subjected to MMI VIII and higher. Further, assistance operations are more likely to become difficult--and hence require prior planning—in urbanized areas where population and industries congregate.
2. The 125–150 counties (in seven States) falling within MMI isoseimals VIII and higher. Communities difficult to reach, potential inundation areas downstream from major dams, and areas adjacent to large industries that might use harmful products should receive special attention.
3. Cities of 100,000 population or over falling within MMI VII.
4. Counties falling within MMI VII.

A special class of problems is posed within this region by the potential failure of dams and petroleum product pipelines, the failure of which could cause large sec-

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ondary impacts. Table 2 reviews current results of the ongoing survey of dam safety by the Corps of Engineers.

TABLE 2.—HIGH HAZARD DAMS IN THE CENTRAL U.S. (9)

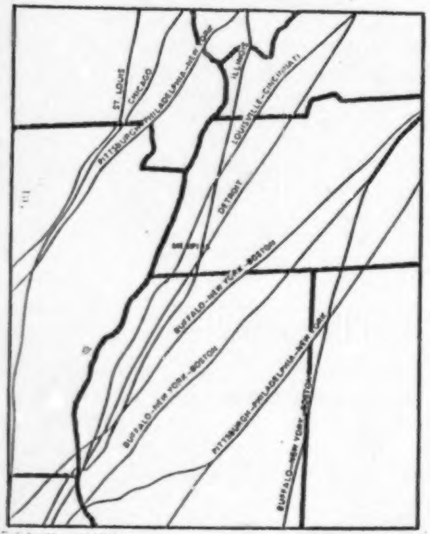
	High hazard	Unsafe	Urgent
Missouri	644	389	42
Illinois	125	20	1
Indiana	235	68	3
Kentucky	210	75	5
Tennessee	145	66	2
Arkansas	129	39	2
Mississippi	77	36	4

Note.—A "high hazard" dam is one whose failure would cause substantial loss of life, while an "unsafe dam" is one judged to be inadequate structurally to withstand expected loading conditions. "Urgent" denotes those facilities which are judged to pose imminent failure risks which must be resolved immediately. Unsafe dams include those which have inadequate spillway capacity, degraded structural properties, or any of a variety of other defects which pose a substantial probability of failure under regularly expected conditions.

Few dams in this region have been designed to withstand earthquake loads (the Corps' assessment included earthquake considerations). The superimposition of earthquake loads on an inventory of already unsafe structures suggests that a substantial number of dam failures can reasonably be expected in any major earthquake which affects the Central United states. This situation tends to be exacerbated by the fact that the predominately earthen dams at risk are particularly vulnerable to the long-period oscillations expected to propagate very efficiently over long distances from such earthquakes.

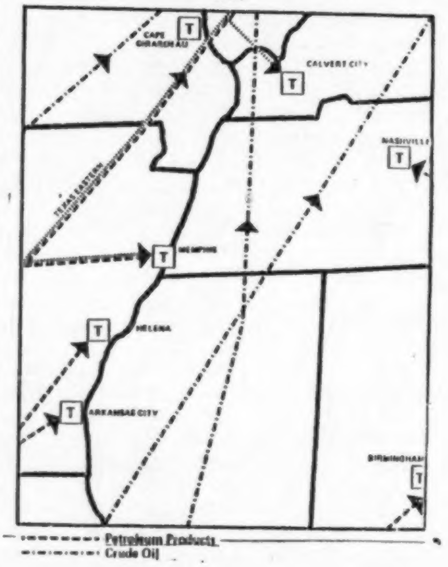
Many interstate natural gas and petroleum product pipelines traverse the areas where strong ground shaking or induced soil failure could cause damage. (Figs. 4 and 5) Other major lifelines (railroads, telecommunications, inland waterways, electric power network) are similarly located. The important characteristic of damage to many of these so-called critical facilities is that the secondary costs of their damage (e.g. interruption of service, fire,) far exceed the loss to the facility itself. Task I.2 is intended to assess the vulnerability of such facilities as a special topic. While it may be reasoned that failure of dams and petroleum pipelines are secondary hazards, the safety of each has high public salience. Thus, a focus on these specific types of facilities may offer access to the public process which is not readily available through other channels. After such issues are aired, it may be easier to address in public forums the more pervasive earthquake hazards.

FIGURE 4
NATURAL GAS PIPELINES
([1])



NOTE: THE ISOSEISMAL FOR MMI VI COVERS VIRTUALLY THE ENTIRE

FIGURE 5
PETROLEUM PRODUCTS PIPELINES
([25])



Our understanding of risks and vulnerability in this region are changing quickly, especially with the emphasis being given by the USGS on such studies. Many researchers within universities and government are focusing considerable effort to unravel the geology and seismology of the region. This, coupled with the evolving understanding of what is required for adequate preparedness and mitigation, require the planned conduct of vulnerability reassessments and of special-purpose on-site studies (Tasks I.3–I.6). Two such special-purpose studies are already tentatively identified. First, an analysis of vulnerability in cities removed from the areas of strong impacts but subject to long-period ground motion that might affect tall (25–30 story and higher) structures (Task I.3) the geologic properties of this area indicate that strong, long-period earth motions may be felt as much greater distances than observed in the western part of the country. Short period earth motions are expected to decay rapidly by comparison. Generally speaking, tall structures are more vulnerable to long-period excitation, while short structures are relatively unaffected. This segment would require some prior geotechnical investigations of distances to which such motion might travel, its characteristics, and the potential impacts on long-period structures. Feasible structural and non-structural measures to provide protection to occupants of these structures should also be identified. Second, the special problems posed to facilities and installations of particular national security importance or of national economic importance (Task I.6). There is a need to identify facilities contributing to national defense that are at risk, so plans can be made to cope with their loss. Similarly, this area makes a major contribution to the country's Gross National Product. The widespread dislocation in employment, production of new materials and semi-finished goods, financial and other kinds of services, and employment could be large enough to impact the national economy. This would be especially significant if the country were faced with serious economic problems at the time of the earthquake, such as high inflation, high unemployment or similar structural economic difficulties.

The importance of building earthquake hazards reduction initiatives from the local level cannot be overemphasized. If the disaster period is to be managed competently, State and local governments must have realistic expectations of what the Federal Government can and will do; and, the Federal Government must have realistic expectations of what State and local governments can and will do. All indications are that a major earthquake will make demands far exceeding the response capabilities of any element of government. These considerations put a premium on thoughtful, long-term Federal, State, local and private sector planning. A key to successfully meeting the earthquake challenge will be for the Federal Government should assist in a way that reinforces and supports local initiatives, and not disrupt, preempt, or impede them. Without a true partnership in Federal, State and local

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earthquake preparedness program planning, severe problems in emergency response and recovery operations will arise following a major earthquake.

Any comprehensive effort to enhance preparedness for a major earthquake must be based upon the recognition that: No element of government has sufficient resources to "go it alone" should a major earthquake occur or be predicted; different elements of government and the private sector must act in cooperation; local organizations must take the principal leadership for they bear the brunt of the emergency; the problem of earthquake preparedness is essentially and foremost one of management—whether in the allocation of responsibility, the distribution of resources, or the resolution of conflict; mitigation activities are integral with preparedness to achieve acceptable levels of earthquake safety; and we must prepare now and not depend upon luck and our ability to improvise when the big event comes.

These observations, benign as they may appear, represent a major transformation in the traditional approach to preparedness planning and dictate a substantial change in institutional relationships. The cooperative approach is one of equal partners with dominant concern for achieving a workable, local capability to prepare for and respond to a damaging event. Because each element of government would participate in the design and management of this program, they would share the responsibility for error.

Tasks II.1 through II.3 are sequentially designed to involve more and more institutions and key individuals in the design of the program which can evolve from this proposal. Such individuals should be drawn from local, substate, State, regional, and national organizations, since preparedness and response will require close cooperation and coordination among all. At the first stage (Task II.1) a limited group, possibly as many as 15 or 20 individuals is convened to participate in initial design discussions and studies. Under their direction, one or two pilot planning efforts could be conducted at the county level (Task II.4). The purpose of these studies is to provide group-level experience, not to develop specific response plans. Task II.2 represents an extension of participation from the individual to the institutional level, based upon experience gained. During Task II.1 each person serves without specific organizational portfolio, while in Task II.2 organizations (principally governmental, professional, and public interest) assume principal responsibility through their representatives. By the initiation of Task II.3 this planning group has matured in its experience and perspective to assume overall management responsibility for the establishment of a joint project team (Task II.5), the initiation of planning partner arrangements (Task II.6), the formation of functional task teams (Task II.8) which prepare specific preparedness and mitigation modules for use by the planning partners, and ultimately replication throughout the region (Task II.7). To assure utility and workability, special care must be exercised to involved all elements of government (local, State and Federal) and the private sector as equal partners.

Success of the planning process invisaged in Tasks II.1 through II.8 will depend on and be limited by first the completion of vulnerability analyses (Tasks I.1–2), second, the development of codes, standards, building practices, and land use procedures which are customized to the specific problems and capabilities of the region, and third, with a technical basis for repair or upgrading of substandard structures. The Applied Technology Council (10) and Building Seismic Safety Council have made great strides in developing nationally applicable earthquake resistant building design practices, but prior to their incorporation into locally applicable codes, they will have to be evaluated and customized for local use (Task II–9), particularly for application in rural and small town settings. Similarly, questions of assessing the hazard of particular building sites, and incorporation of hazards into locally enforced land use regulation must be developed (Task II–10). While experience in other geographic areas will be of utility, this effort will need careful, local consideration and development. Tasks II–11 and II–12 are designed to specifically develop technical guidelines for the identification and upgrading of hazardous structures and the adaption of hazard reduction practices for critical facilities. Tasks 9–13 are also intended to give technical individuals who are highly motivated a base from which to be more effective as they seize opportunitunities to effect decisions within their area of expetise. It is particularly important to note that earthquake resistant design is not costly when it is undertaken as part of the original design effort. Periodic peer evaluation (Tasks II.13 through 16) by those within the affected communities and experts in science and engineering is a vital tool to assure quality and applicability. A delicate balance must be maintained throughout Tasks II.1 through 16, while constantly striving for wide involvement, we must also identify, cultivate and nurture key long-term individual participants. Wide participation can become thin veneer, especially if there is not a simultaneous development of a few key people who can make sustained contributions. It is expected that as each task progresses opportunities to improve earthquake safety through legislation and administrative action will be continual and actions to implement them will take place as they occur.

It is not expected that a basic integrated preparedness and mitigation program will be in place for at least five years. Thus it is incumbent on Federal and State organizations, at the minimum, to prepare interim adaptations and stop-gap additions to existing emergency plans (Task III.1). This will be required particularly for those critical facilities identified as high hazard in Task I.2 and I.6 see also (Tasks III.2 and 3). These latter plans should be based on models prepared for specific site application.

Much of what we know about earthquake hazards in the Central United States has been developed by individual research investigations generally working alone on topics identified by themselves. The U.S. Geological Survey has initiated specific hazard assessment studies and the National Science Foundation has supported engineering and policy studies. These have been few in number, and occasionally performed outside the region. The conduct of more research on and within the region not only will increase our knowledge, but also add to the cohort of "experts" with local perspectives who can consult and participate in local earthquake hazards reduction. Federal and State research supporting and performing organizations should be encouraged to commit more time, expertise and resources. Of equal importance is the identification of research topics and information needs of the professions, businesses, and government within the region. In cooperation with the research community, the multijurisdictional planning group (Tasks II-1 through II-12), and representatives of affected communities, a substantial continuing effort to identify research needs and priorities is required (Task IV.1).

Clearly, one pressing need is to determine the institutional framework in which earthquake safety decisions will be made (Task IV.3). There are seven States whose territory will receive from severe to moderate direct and indirect damage. That number can easily double when indirect and long-period consequences are calculated. They have different legislative structures, perceptions, and attitudes toward seismic hazards; they are in different stages of economic development with varying social characteristics. Local autonomy, probably strong in all of them, nonetheless exhibits marked differences from one State to the next as does the capability to act and interest. The same is also true of the organizational and legal structures of substate and local entities and of planning units. The Federal structure involves four or more regions that often cut across the boundaries of organizations such as the Army Corps of Engineers. The intergovernmental structure needs to be clearly understood, and influentials identified, and an overall approach designed so that coordination, awareness, and education efforts can be targeted, and mutually supporting institutional arrangements can be established between the seismic safety planning group and existing State, local, and Federal agencies.

As more investigators become involved, meetings to coordinate research and identify results which should be disseminated will be required, perhaps on an annual basis (Task IV.12 through 15). These meetings also will serve the purpose of identifying new research needs, preventing overlaps and generally giving focus and direction to the research effort. Stronger interest in earthquake preparedness in this area can be expected to be fostered throughout the research and academic establishments with the consequent recruitment of capable investigators into the effort. The USGS specialty research conferences are models of the meetings that we have in mind here (Tasks IV.12 through 15).

In a number of States, professional societies of engineers, architects, planners and public administrators, and individuals in these constituencies have played a key role in initiating, leading and encouraging earthquake hazards reduction measures in State and local governments. These types of associations and their members should be the subject of special professional development efforts beginning early in the planning process (Task IV.3 through 10). The design of a wider professional education program (Task IV.11) is intended to help guide this semiannual effort. A first seminar should be held on the state-of-the-art and the results of seismic planning efforts in other parts of the country. Subsequent seminars directed at specific audiences should be held perhaps every six months, constantly striving to reach wider and wider audiencies. Thus, building knowledge and broader capability incrementally until the point is reached where the media and public can be involved. A word of caution is in order at this point. Experience shows that research results need to be put through a "translation effort" in order to have an impact on decisions and practices. The new information must be interpreted and adapted to the different needs of the various audiences we want to reach, otherwise it will be left unused on bookshelves. Further, the meetings should be structured around a minimum of instruction and a maximum of discussions and exercises.

Active raising of awareness among the general public and enlisting their assistance in both self-help and community action should come later, perhaps in the fifth year of our proposed planning effort. This is not to say that the general public should be kept in the dark or be excluded. It merely means we must have information available that is reliable and ready for action on their part. Their involvement then will allow them to gain a proper perception of the hazards, undertake useful measures to protect themselves, and decide how best to join the effort. Premature involvement will only cause needless apprehension and waste much needed energy in a non-productive way. Prior to such an effort, well considered products should be made available to groups participating in the tasks that have been enumerated or making a specific request.

This workshop has organized its discussion in six tropical areas: Topic 1—Hazard awareness and public information; Topic 2—Public sector participation; Topic 3—Intergovernmental and organizational relations; Topic 4—Local earthquake resistance design. Topic 5—land use; and Topic 6—Response to a damaging earthquake.

Further, the workshop has separated its planning activity into three geographic areas for consideration: central, southeastern and northeastern United States. While the program proposal of Table 4 is not presented in terms of these topics, they are implicit in the variety of tasks to be performed. Table 3 presents our estimates of the relationship between tasks and topics. Two notations are given: P—principal relationship; S—major supporting relationship. Some tasks, for instance Task IV.1, pertaining to research encouragement, are not specific to any of the topics, but supportive of all.

This planning approach is presented as a proposed course of action. It is hoped that through the discussions that it will generate, a more refined and definitive planning document will evolve.

Acknowledgement: This paper is based upon the authors' more extensive paper "An Approach to Seismic Safety in the Central United States," presented at the Conference on Earthquakes and Earthquake Engineering: the Eastern United States, Knoxville, Tennessee, September 14-16, 1981. The insightful reviews of this paper by our colleagues—Claire Rubin, Karl Steinbrugge, Walter Hays, Anshel Schiff, William Hall, Otto Nuttli, Delbert Ward, Hilary Whitaker, Charles Fritz, and Robert Olson—have been of great utility in preparing this second generation approach to improving seismic safety in the Central United States.

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